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(AGRICULTURAL RESEARCH SECTION)

CONTENTS

	PAGE
Studies in Monozygotic Cattle Twins. VI. *J. Hancock*	131
A Comparison of Breeds of Ram for Fat-lamb Production. *I. E. Coop* and *V. R. Clark*	153
Glasshouse Tests of Organic Insecticides Against Aphids on Swedes. *H. Jacks* and *K. P. Lamb*	172
Materials Suitable for Use as Grafting Mastics. *C. A. S. Padfield*	179
Sodium Alginate and Carboxymethyl Cellulose as Substitutes for Rotted Organic Material in Soil Mixtures. *J. A. Hunter*	186
Virus Infection in Certified Seed Potatoes. *C. H. Procter*	192
Review: Journal of Soil Science	194
Methods for Determining the Viability of Various Seeds by Tetrazolium Staining. *E. O. C. Hyde*	195
Seed Disinfection. III. *H. Jacks*	202
Seed Disinfection. IV. *H. Jacks*	206
Review: The Association of Ants with Aphids and Coccids	208
DDT and Arsenic Residues in Fruit. *P. J. Clark* and *E. L. Richards*	209
Review: Gall Midges of Economic Importance. Vol. V. Trees	212
Preparation of Radioactive Phosphate Fertilizer for Field Experiments. *T. A. Rafter, K. N. Baigent, W. J. McCabe* and *W. J. Ritchie*	213
Note on Occurrence of a Tobacco-necrosis Virus in Roots of Lettuce Showing Big-vein. *P. R. Fry*	224
Note on DDT Residues on Cabbages. *P. J. Clark, E. L. Richards, G. G. Taylor* and *H. Jacks*	226
Note on Zinc Deficiency of Citrus at Aitutaki, Cook Islands. *W. B. Healy*	228
Note on Agronomic Effect of the Endophyte of *Lolium*. *J. C. Neill*	230

NOTICES

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VOL. 34. SEC. A AUGUST 1952 NUMBER 2

STUDIES IN MONOZYGOTIC CATTLE TWINS

VI. UNIFORMITY TRIALS: PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERISTICS

By JOHN HANCOCK, Ruakura Animal Research Station, Animal Research Division, Department of Agriculture, Hamilton

(*Received for publication, 25 June 1951*)

Summary

The usefulness of monozygotic cattle twins in experiments involving various physiological and biochemical traits has been estimated from uniformity trials. The following twin-efficiency values have been calculated:

Characteristic	*Twin-Efficiency Value*
Red cell count	4
Red cell volume	8
Hæmoglobin content	13
Red cell fragility	15
B'ood calcium	1
Blood magnesium	19
Blood phosphorus	15
Blood sugar	1
Total blood acetone bodies	1
Body temperature	37
Respiration rates	15
Dry matter intake (pasture)	8
Fæcal nitrogen concentration	21
Dry matter content of fæces	5
Milk fat Reichert-Meissl value	11
Milk fat Iodine value	4
Milk fat softening point	1
Milk fat saponification value	9
Fæcal egg count	$2\frac{1}{2}$
Titre response to *Br. abortus* vaccination	2

INTRODUCTION

In this paper, the last in a series dealing with the uniformity of monozygotic cattle twins,[1, 2, 3] attention is given to a number of physiological and biochemical characteristics. The selection of the characteristics studied was generally governed by their relative importance to

the main lines of current dairy husbandry research at Ruakura. Of necessity, it was not possible to measure all the characteristics at the same time or even on the same sample of twins. The twin efficiency values, computed according to the method described in a previous paper[1] are therefore not strictly comparable, but should nevertheless provide a rough guide to the usefulness of monozygotic twins for experimental work involving the measurement of the characteristics under consideration.

In this paper it is assumed for the sake of simplicity that the "between-set" differences demonstrated to occur, were entirely due to genetical factors, although it is realised that at least a part of these differences may be due to peculiarities in the common prenatal environment of each twin set.

PHYSIOLOGICAL AND BIOLOGICAL CHARACTERISTICS EXAMINED

The present study was undertaken in order to discover whether monozygotic twins could be used with advantage in experimental work on cattle involving the following characteristics:

A. Blood Characteristics.
B. Tolerance to heat.
C. Food Intake.
D. Milk Composition.
E. Fæcal Egg Counts.
F. Response to Vaccination.

A. *Blood Characteristics*

Ferguson *et al.*[4] in a paper on the variation in the blood cells of healthy cattle, quoted Burnett[5] as follows: "The past quarter of a century is marked in medicine by great advances made in the knowledge of the causes and nature of disease processes and in the acquisition of more delicate means of detecting the presence of these processes. The practitioner now has available many aids for making a diagnosis that were unheard of by the former generation. Among the recent methods of examination, that of the blood has taken a prominent place. . . . A study of blood is undoubtedly of even greater importance in veterinary than in human practice for the veterinarian is necessarily restricted to the use of objective symptoms as he cannot communicate with his patients. . . ."

Bell and Irwin[6] called attention to the need for more accurate measurement of the variation of blood constituents to be expected in normal animals. They contended that if such information was available, it could be used as a yardstick with which to compare the fluctuations in the blood characters in various diseases.

Blood characteristics are discussed under two main headings:—

(1) Physiological characteristics
(2) Chemical characteristics

(1) *Physiological characteristics*

Some disorders of the blood, such as various anaemias, can be diagnosed by the determination of a number of values, of which the mean corpuscular volume (M.C.V.) and the mean corpuscular hæmoglobin concentration (M.C.H.C.) are the most important[7]. As the M.C.V. is a function of the red cell volume and red cell count, and the M.C.H.C.

a function of the hæmoglobin concentration and the red cell volume, the following characteristics were selected as subjects for investigation: (*a*) red cell count; (*b*) red cell volume; (*c*) hæmoglobin concentration; and, in addition, (*d*) red cell fragility.

Thirteen sets of approximately 18 months old twin heifers were available. Three samples of venous blood were taken with approximately fortnightly intervals between the samplings. Hæmoglobin and red cell volume were estimated for only eleven sets. In the study of the red cell fragility another sample of twins was employed, which will be described later.

(a) *Red cell count*: Standard hemocytometers and pipettes were used in making total counts. The results are plotted in Fig. 1. The twins showed fairly good concordance in this characteristic. The average within-set difference was 19.7 x 10^4 cells/ml blood, while the difference between the extreme sets was 145 x 10^4 cells/ml blood. The analysis of variance is shown in Table I.

TABLE I. ANALYSIS OF VARIANCE: Red Cell Count

Source of Variation	df	ss	ms	Significance
Between sets	11	124911	11356	SS
Within sets	12	15161	1263	S
Between days	2	4261	2131	NS
Days x Sets	22	72447	3293	SS
Residue	24	13748	593	
Total	71	230528		

The highly significant between-set difference indicates that genetically determined individuality is an important factor in setting the level for the total count of red cells, while the significant within-set term shows that at least some individual variation is acquired. Ferguson *et al.*[4] found in an exhaustive trial that individuality, as measured by the between-cow variance accounted for a significant part of the total

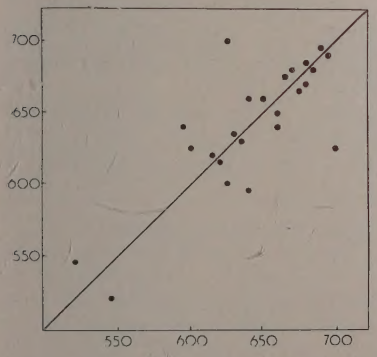

FIG. 1.—The 8-days average red cell count (10^4 cells/ml blood); 12* sets.

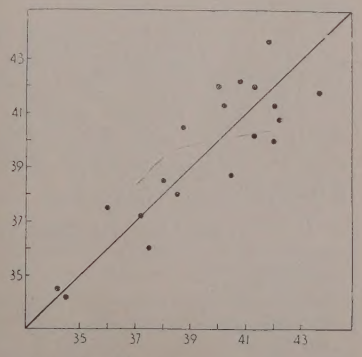

FIG. 2.—The 3-days average red cell volume; 11 sets.

* Indicates the number of sets of twins in the sample taken.

variation, although his data did not permit its computation. Rusoff and Piercy[8] could not, on the other hand, demonstrate significant between cow differences. In the present study, 36 per cent of the total variance was due to the between-set differences, 7 per cent to the within-set differences, and no less than 40 per cent to the days x sets interaction. The magnitude of the last mentioned term may partly explain why differences due to individuality sometimes can be difficult to detect in trials in which individuality is measured by between-cow differences. In such trials, the interaction term, sampling day x cow, cannot be separated from the error variance which is thus correspondingly increased, making the test for individuality much less sensitive than in studies in which monozygotic twins are used as experimental material. The twin efficiency value was calculated as 4.

(b) *Red cell volume*: Red cell volume was estimated by Wintrobe's method[9]. The results are plotted in Fig. 2.

The twins showed quite a good concordance: the average within-set difference was fairly small 1.1 ml/100 ml blood when compared with a difference of 8.4 ml/100 ml blood between the two extreme sets. The analysis of variance is shown in Table II.

TABLE II. ANALYSIS OF VARIANCE: Red Cell Volume

Source of Variation	df	ss	ms	Significance
Between sets	9	385	42.3	SS
Within sets	10	25	2.5	NS
Between days	2	15	7.4	NS
Days x Sets	18	105	5.8	SS
Residue	20	31	1.5	
Total	59	561		

Of the total variation, almost 60 per cent was due to between-set differences, only 3 per cent due to within-set differences, while the interaction between sampling days and sets accounted for 21 per cent. The genotype of an animal is therefore an important factor in the determination of its red cell volume. The twin efficiency value was reasonably high, viz. 8.

(c) *Haemoglobin content*: Hæmoglobin was estimated by the use of a Hellige Hemoglobinometer, and expressed as grams of hæmoglobin per 100 ml of blood. The results are shown in Fig. 3.

The twins showed excellent concordance. The average within set difference was only 0.22 g/100 ml, while the differences between the extreme sets amounted to 2.2 g/100 ml. The analysis of variance is presented in Table III.

TABLE III. ANALYSIS OF VARIANCE: Hæmoglobin content

Source of Variation	df	ss	ms	Significance
Between sets	9	25.4	2.8	S
Within sets	10	1.1	0.1	NS
Between days	2	2.7	1.3	NS
Days x Sets	18	18.1	1.0	SS
Residue	20	1.4	0.1	
Total	59	48.7		

The between-set differences accounted for 34 per cent of the total variation, while differences within sets accounted for only 1 per cent. The interaction between days and sets was important as shown by the fact that 54 per cent of the total variation was due to this term. The twin efficiency value was relatively high, viz. 13.

(d) *Red cell fragility*: In human medicine red cell fragility is used in differential diagnoses of various types of jaundice and anæmia. It has been shown[10] that racial variations also occur.

In cattle, red cell fragility is altered in a number of pathological conditions. For critical work on the blood status in such conditions it is desirable to obtain a measure of the normal individual variations which exist. The red cell fragility was measured in 25 sets of monozygotic yearling heifer twins, which had been reared together from an early age. The following method based on Creed's technique[11] was used.

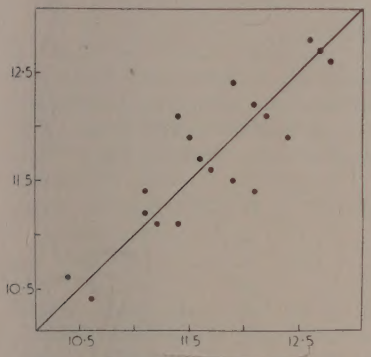

FIG. 3.—The 3-days average hæmoglobin content; 11 sets.

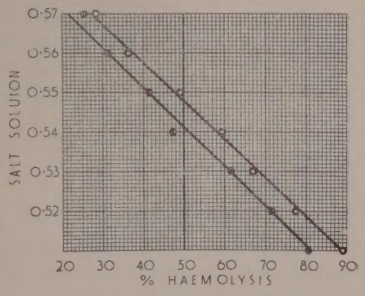

FIG. 4.—Graphical method of estimating red cell fragility.

A 10 per cent Na Cl solution was diluted to provide a series of solutions ranging in concentration from 0.47 per cent to 0.50 per cent by 0.01 per cent intervals. The concentration of each solution was checked and standardised with 0.1N $Ag\,NO_3$ and $K_2\,Cr_2\,O_3$ as indicators. Oxalated venous blood prepared in the manner described by Wintrobe and Landsberg[12] was used. After a preliminary trial to determine the approximate fragility of the blood under test, 15 ml centrifuge tubes were filled with 10 ml of each of seven consecutive salt solutions; 10 ml distilled water was placed in an eights tube. Two drops of blood from a small pipette were then placed slowly into each tube. The tubes were shaken gently and subsequently centrifuged for 15 min at 2500 r.p.m. Hæmolysis was naturally complete in the tube containing water. The supernatant fluid of this tube was decanted and made up to twice its volume by the addition of distilled water. This solution now provided a 50 per cent hæmolysis standard, against which the degrees of hæmolysis which had taken place in the various salt solutions, were immediately measured using a Klett colorimeter. The values thus obtained were plotted, and the respective salt solutions and a regression line fitted by eye. From this line, the mean red cell fragility could be determined as the saline concentration in which 50 per cent of hæmolysis occurs. Fig. 4 illustrates the graphical technique employed.

The results of the measurements of the mean red cell fragility in the above sample of monozygotic twins are presented as a scattergram in Fig. 5.

It can be seen that the members of the same sets of twins show excellent concordance. Although the range between sets was not great, viz. only 11.6 per cent, the differences within-sets were correspondingly small, averaging only 0.01 per cent.

The analysis of variance (Table IV) shows that the differences between sets are highly significant. The twin efficiency value was high, viz. 15.

TABLE IV. ANALYSIS OF VARIANCE: Mean red cell fragility

Source of Variation	df	ss	ms	Significance
Between sets	24	0.0518	0.0022	SS
Within sets	25	0.0017	0.0007	
Total	49	0.0535		

It is thus evident that red cell fragility is a characteristic which, in cattle, depends in a high degree on individuality. Comparative studies[13] on various species of domestic animals have shown that fragility is related to the shape of the red cells—the nearer the shape is to spherical the greater is the fragility. It is thus quite possible that the differences shown to occur between sets of twins are due to differences in the shape of their red cells.

(2) *Chemical Characteristics*

Disturbances of the mineral balance of the blood are characteristic of the most important metabolic diseases occurring under New Zealand grassland conditions. Depressed calcium in milk fever, depressed magnesium in grass staggers, and increased quantities of acetone bodies in ketosis are three obvious examples. Some of the difficulties encountered in investigations of these disorders have undoubtedly been due to the great individual variability cattle show in their reaction to identical environmental circumstances. In order to measure the usefulness of monozygotic twins for experimental work on the mineral balance of the blood, the following tests were carried out on the bloods of nineteen sets of monozygotic twin heifers:

(a) Calcium;
(b) Magnesium;
(c) Phosphorus;
(d) Sugar;
(e) Total acetone bodies.

The animals were approximately 4½ months old at the time of the test. They were all born within a time-span of twenty days and had been reared together. A sufficient amount of blood was drawn in one bleeding to allow determinations to be carried out on all five substances. The analyses were made by Mr. R. White of the Biochemical Section of this Station.

(a) *Serum Calcium*: Calcium was estimated according to the method of Clark and Collip[14] in duplicates. The results are shown graphically in Fig. 6.

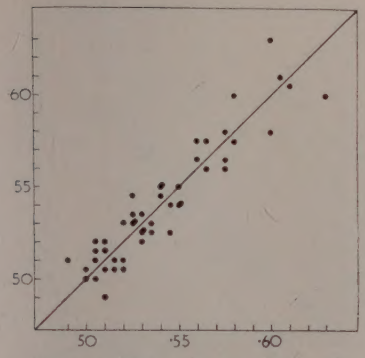

FIG. 5.—Red cell fragility; 25 sets.

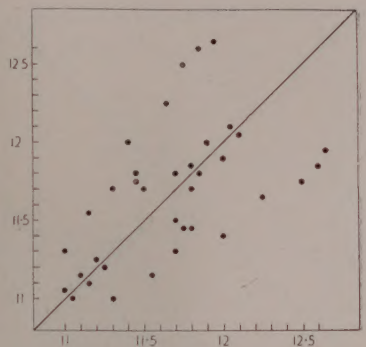

FIG. 6.—Blood calcium (mg/100 ml); 19 sets.

It can be seen that: (a) there was not a good concordance between the members of the same sets; and (b) that the range between the sets was small. The average within-set differences were calculated as 0.33 mg/100 ml, while the range between the highest and lowest testing sets was only 1.35 mg/100 ml.

The analysis of variance is shown in Table V.

TABLE V. ANALYSIS OF VARIANCE: Calcium

Source of Variation	df	ss	ms	Significance
Between sets	18	5.22	0.290	SS
Within sets	19	1.62	0.085	
Total	37	6.84		

The between-set differences are highly significant, indicating that differences in the level of serum calcium occur which are genetically determined. In the present studies, 54 per cent of the total variations were due to between-set differences. This is in accordance with Hansson's[15] findings, based on similar material. The relatively low between-set variance and high within-set variance, however, resulted in low twin-efficiency value of 1.2. Monozygotic twins are, therefore, only 20 per cent more efficient than random animals in trials involving serum calcium.

(b) *Serum Magnesium*: Serum magnesium was estimated in duplicate according to the method of Cunningham and Josland[16]. The results, shown graphically in Fig. 7, indicate that although the difference between extreme sets was not very great, viz. 0.9, the within-set differences were correspondingly much smaller, or on an average only 0.05 mg/100 ml. The analysis of variance is presented in Table VI.

TABLE VI. ANALYSIS OF VARIANCE: Magnesium

Source of Variation	df	ss	ms	Significance
Between sets	18	1.80	0.1002	SS
Within sets	19	0.05	0.0026	
Total	37	1.85		

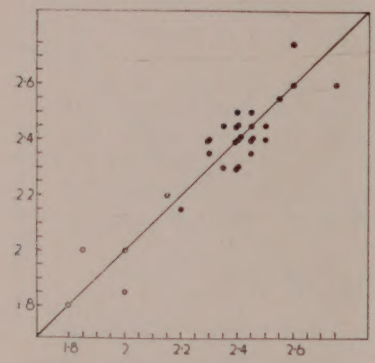

FIG. 7.—Blood magnesium (mg/100 ml); 19 sets.

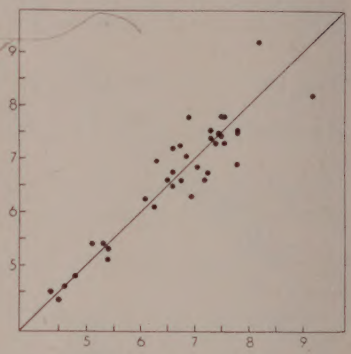

FIG. 8.—Blood phosphorus (mg/100 ml); 19 sets.

Of the total variation, 95 per cent was due to between-set differences. As a result of the high between-set variance relative to the within-set variance, the twin efficiency value was high, viz. 19, indicating the great value of monozygotic twins in experimental work involving the measurement of serum magnesium levels.

(c) *Phosphorus*: Whole blood inorganic phosphorus was estimated in duplicates according to the method of Briggs[17]. As can be seen from Fig. 8, the range found in the phosphorus values was great. The difference between the highest and lowest testing sets amounted to 4.1 mg/100 ml. The differences within sets were relatively small or on an average only 0.3 mg/100 ml. The analysis of variance is presented in Table VII.

TABLE VII. ANALYSIS OF VARIANCE: Phosphorus

Source of Variation	df	ss	ms	Significance
Between sets	18	50.21	2.79	SS
Within sets	19	1.69	0.09	
Total	37	51.90		

The between-set differences accounted for 94 per cent of the total variation. The high between-set variance relative to the within-set variance resulted in the high twin-efficiency value of 15, which is a measure of the great usefulness of monozygotic twins in cattle trials involving the measurement of the phosphorus level of the blood. Hansson's[15] study on three sets of twins yielded similar results.

(d) *Blood sugar*: Whole blood sugar was estimated in duplicates by the method of Somogyi[18]. Through an accident, bloods of only 18 sets of the twins were available for analysis. The results shown in Fig. 9 indicate that monozygotic twins show little within-set similarities. The range between the highest and lowest testing twins was small (16.5 mg/100 ml) relative to the average within-set difference of 6.4 mg/100 ml. The analysis of variance is presented in Table VIII.

Only 17 per cent of the total variation was due to between-set differences.

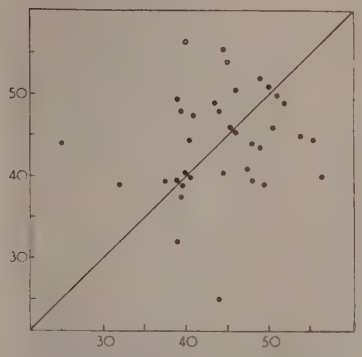

FIG. 9.—Blood sugar (mg/100 ml); 19 sets.

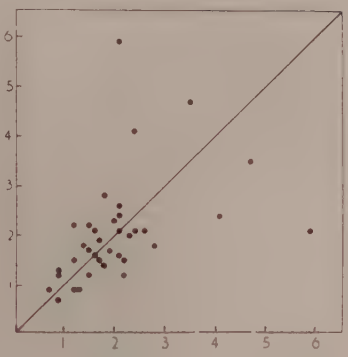

FIG. 10.—Total acetone bodies (mg/100 ml); 19 sets.

TABLE VIII. ANALYSIS OF VARIANCE: Blood-sugar

Source of Variation	df	ss	ms	Significance
Between sets	17	8.2	0.48	NS
Within sets	18	6.1	0.34	
Total	35	14.3		

Although the between-set variance was greater than the variance within-sets, the difference was not significant. It seems, therefore, that not easily controllable environmental factors are sufficiently strong to mark the effects of differences due to genetical factors if such differences indeed occur. This is perhaps not surprising in view of the fact that such factors as exercise, emotion, etc., are known to alter the blood-sugar level materially. The twin efficiency value was below unity, indicating that monozygotic twins are no more useful in investigations on factors affecting blood-sugar than are animals chosen at random.

(e) *Total Acetone bodies*: Whole blood total acetone bodies were determined colorimetrically[19] after oxidation, according to the method of Greenberg and Lester[20]. The sets in this sample of twins did not show a good concordance, as Fig. 10 indicates. The range 3.2 mg/100 ml was relatively small, compared with the average within-set difference of 0.7 mg/100 ml. The analysis of variance appears in Table IX.

TABLE IX. ANALYSIS OF VARIANCE: Total Acetone Bodies

Source of Variation	df	ss	ms	Significance
Between sets	18	29.0	1.6	S
Within sets	19	11.3	0.6	
Total	37	40.3		

Of the total variation, 45 per cent was caused by the between-set differences. The significant between-set term indicates that genetical factors determine the level of acetone bodies in the blood to a certain extent. However, the within-set differences were sufficiently great to cause the twin-efficiency value to fall below unity.

B. *Tolerance to Heat*

In recent years a great deal of attention has been given to the problem of the adaptability of cattle to tropical environments[21]. A considerable part of this work has been directed towards defining the physiological reaction of cattle to high temperatures. As a result, the body temperature and respiration rate have been accepted generally as sensitive indicators of a cattle beast's ability to withstand hot atmospheric conditions. Significant breed differences in heat tolerance have been shown to occur[22, 23].

Seath[24] has estimated that within a herd, inheritance accounts for 15-30 per cent of the total variation in body temperature, and for 75-85 per cent of respiration rate. In studies of another herd, Galaas[25], however, could not demonstrate inter-sire differences.

In order to discover the specific usefulness of monozygotic twins for experimental work on heat adaptability phenomena, the following trials were carried out.

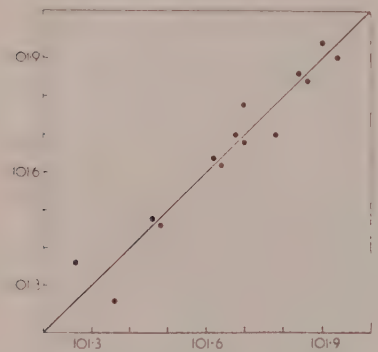

FIG. 11.—The 5-days average body temperatures (F°); 7 sets.

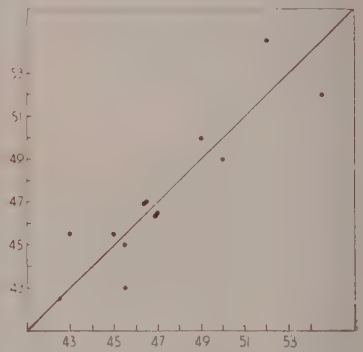

FIG. 12.—The 5-days average respiration rates (resp./min); 7 sets.

(1) *Body temperatures*

Rectal temperatures were measured in seven sets of 18 months old monozygotic twin heifers on five different days. The air temperatures varied between 75° and 85°F.

As shown in Fig. 11 there was a good concordance. The average within-set difference was only 0.04°, while the difference between the two sets showing extreme body temperature response was 0.5°.

The analysis of variance is presented in Table X.

TABLE X. ANALYSIS OF VARIANCE: Body temperatures

Source of Variation	df	ss	ms	Significance
Between sets	6	2.69	0.448	SS
Within sets	7	0.04	0.006	NS
Between days	4	2.44	0.611	SS
Days x sets	24	1.46	0.061	SS
Residue	28	0.50	0.018	
Total	69	7.13		

Of the total variation 33½ per cent was due to the between-set differences, 33 per cent to the differences between days and 18½ per cent to the days x sets interaction. The fairly poor repeatability of individual body temperature records for the same cows reported by Seath[24] can be explained, at least partly, by the relatively large interaction between environment and inheritance which in the present trials has been demonstrated to occur.

The calculation of the efficiency of monozygotic twins resulted in the high value of 37.

(2) *Respiration rates*

Flank movements were counted for three consecutive half minute periods. The respiration rates were computed as the average of the three counts multiplied by two.

The results presented in Fig. 12 show that the twins showed a good concordance. The average within-set difference was fairly small, 1 respiration per minute when compared with the difference of 11 respirations per minute between the extreme sets.

The analysis of variance is shown in Table XI.

TABLE XI. ANALYSIS OF VARIANCE: Respiration Rates

Source of Variation	df	ss	ms	Significance
Between sets	6	193.0	31.2	NS
Within sets	7	7.0	1.0	NS
Between days	4	3631.6	907.9	SS
Days x sets	24	435.2	18.1	SS
Residue	28	46.4	1.7	
Total	69	4313.2		

The between-set differences accounted for only 2 per cent of the total variation, while difference due to days accounted for 85 per cent and the days x sets interaction for 11 per cent. The relatively greater effect of varying air temperatures on the respiration rates than on the body temperatures is expected as increased respiration is probably the most important mechanism whereby cattle keep their body temperature as near to normal as possible.

The twin efficiency value was calculated as 15.

C. *Food Intake and Faeces Excretion*

The basic importance of food intake to pasture evaluation studies has been stressed by McMeekan[26]. The following quotation seems pertinent " . . . the greatest single limiting factor to precise studies of animal nutrition on grassland is that imposed by inability to measure the intake of the free grazing animal. The simple question of 'how much does a cow or a sheep eat' or more specifically 'how much have they eaten' leaves the animal worker no alternative to mere speculation in respect to many aspects of animal efficiency and the animal pathologist with hardly a starting point in his attempts to study the nutrition-disease complex. So important do we believe this aspect to be that the measurement of intake under free grazing is a major interest of the Ruakura nutrition team."

Hancock[2] has shown that the individuality of a dairy cow is an important factor in the determination of grazing behaviour and more especially of the time spent in actual grazing, which suggested that food intake also may vary according to individuality. This important aspect was investigated by Lancaster, Wallace, Coup and Percival[27], who measured the intake of a number of free grazing dairy cows over a whole lactation. The animals employed consisted of monozygotic twins, and the accumulated data may consequently be analysed for the influence of genetically determined individuality on intake and for an evaluation of monozygotic twins as experimental animals in further studies of this nature. The present author is therefore very grateful for their permission to analyse a portion of the data from this viewpoint.

(1) *Food Intake*

The average values obtained for each of 12 sets of twins over nine fortnightly periods have been plotted in Fig. 13. It can be seen that the twins show a very good concordance. The range between sets amounted to 2.8 kg, while the average within-set difference was only 0.4 kg dry matter intake.

An analysis of variance is presented in Table XII.

TABLE XII. ANALYSIS OF VARIANCE: Dry matter intake ("Chromium oxide marker and sheep digestibility")

Source of Variation	df	ss	ms	Significance
Between sets	11	157.9	14.4	SS
Within sets	12	10.0	0.8	SS
Between fortnights	8	122.0	15.3	S
Fortnights x sets	88	89.0	1.0	SS
Residue	96	34.8	0.36	
Total	215	413.7		

Of the total variation, 30 per cent was due to between-set differences, and only 2 per cent to within-set differences, while as much as 27½ per cent was due to the fortnight x sets interaction. The significant within-set difference was caused by two sets of twins in which the members

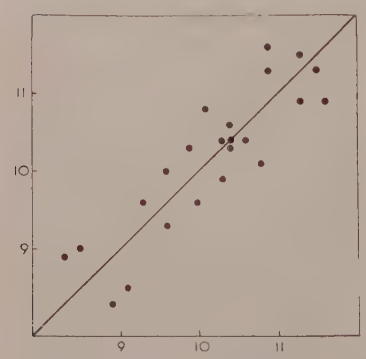

FIG. 13.—Average dry matter intake (kg.) over 9 fortnightly periods; 12 sets.

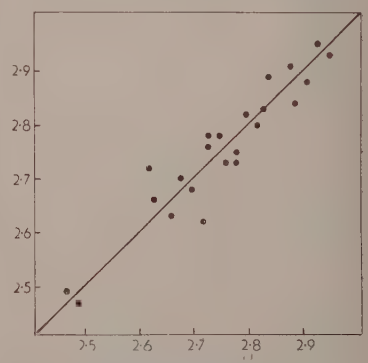

FIG. 14.—Average faecal nitrogen concentration (%N) over 9 fortnightly periods; 12 sets.

differed considerably in their theoretical nutritional requirements. It can be concluded that the inherent individuality determines to an important extent the appetite of an animal, and also that the interaction between environment and inheritance is a potent force in this connection. It is naturally possible that appetite and, therefore, free food intake, is an epiphenomenon depending mainly on nutritional requirements. The elucidation of this point must, however, await a complete analysis of the material. Meanwhile, it has been calculated that the twin efficiency value for dry matter intake under free grazing conditions when measured as in this experiment is relatively high, viz. 8. Measurement by alternative methods gives comparable data so far as twin efficiency values are concerned[27].

(2) *Faecal Nitrogen*

Lancaster[28] observed that there is a constant relationship between faecal nitrogen excretion and digestibility of pasture feed. In view of the importance of this contribution to the development of methods of measuring intake of pasture by free grazing animals, the usefulness of twins for faecal-nitrogen-feed relationship studies is obvious.

The average nitrogen concentrations for 12 sets of twins over nine fortnightly periods have been plotted in Fig. 14. Although the range between sets was not very great, viz. 0.46 per cent, the within-set differences were very small, amounting to only 0.036 per cent. Twin concordance was excellent. Analysis of variance is shown in Table XIII.

TABLE XIII. ANALYSIS OF VARIANCE: Faecal Nitrogen Concentration

Source of Variation	df	ss	ms	Significance
Between sets	11	3.16	0.287	SS
Within sets	12	0.08	0.007	NS
Between fortnights	8	33.53	4.192	SS
Fortnights x sets	88	1.10	0.013	SS
Residue	96	0.70	0.007	
Total	215	38.57		

As the quality of pasture fluctuated rather widely throughout this trial (there was actually a difference of 10 units in the digestibility co-efficient between the extreme fortnights), it is natural that most of the total variation in faecal nitrogen concentration was due to fortnightly variations. However, in spite of the fact that the between-set differences accounted for only 8 per cent of the total variation, this term was highly significant. Practically the whole variation within fortnights was due to the between-set differences. The twin-efficiency value was high, viz. 21. It can thus be concluded that the faecal nitrogen concentration of cows pastured together is almost entirely due to genetically determined cow differences. The raw data for this analysis has been obtained from that reported by Lancaster[27], who has described in detail the possible physiological causes of the variances thus demonstrated, and has considered also their major implications.

(3) *Dry Matter Content of Faeces*

Jarl[30] has shown that the individuality of an animal determines to a large extent the dry matter content of its faeces, and also that there is a significant correlation between the faecal dry-matter content and the

digestive ability of dairy cows. In view of the latter finding, it seemed important to discover whether genetical factors are involved in the determination of the percentage of dry matter in the faeces, and whether monozygotic twins are more useful than random animals in further investigations on this subject.

In the following trial, twelve sets of monozygotic twin heifers were used. They were approximately 9 months of age, and had been reared together practically from birth onwards. Two rectal faeces samples were obtained at a seven days interval. The average percentage dry matter contents for the twins have been plotted in Fig. 15. It can be seen that there was quite a good concordance within sets of twins. The range between the two extreme sets was quite large, 8.4 per cent, while the average within-set difference was only 1.4 per cent. The analysis of variance is shown in Table XIV.

TABLE XIV. ANALYSIS OF VARIANCE: Percentage Dry Matter in Faeces

Source of Variation	df	ss	ms	Significance
Between sets	11	230.7	21.0	NS
Within sets	12	25.5	2.1	NS
Between days	1	63.5	63.5	S
Days x sets	11	114.4	10.4	SS
Residue	12	40.5	3.4	
Total	47	474.6		

Although the between-set differences were not significant, they accounted for nearly 25 per cent of the total variation. The interaction between environment and inheritance was the most important source of variation in that the days x sets term accounted for 29 per cent of the total variation. The twin-efficiency value of nearly 5 indicates the superiority of monozygotic twins over randomly selected animals in experimental work involving the measurement of faecal dry matter. Finally, it can be noted that the residual term accounting for 28 per cent of the variation was relatively large. Partly, at least, this may have been due to the fact that rectal samples are not representative of a whole day's faecal output, and, perhaps, not even representative of a single defaecation.

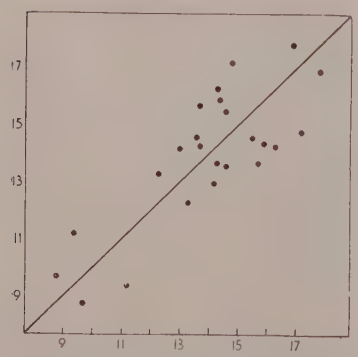

FIG. 15.—The 2-days average faeces dry matter content (%); 12 sets.

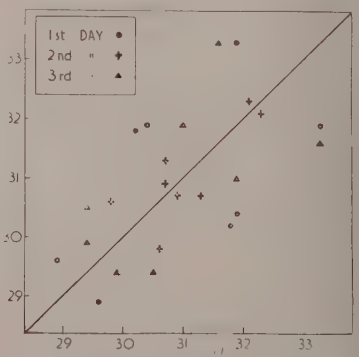

FIG. 16.—The Reichert-Meissl values of butterfat; 4 sets.

D. *Milk Composition*

The successful outcome of the dairy manufacturing processes depends to an important degree on the composition of the milk fat. A glyceride may, for instance, add to the flavour or the nutritive value of the butter when present in a small amount, while the same glyceride present in larger quantity may materially lower the keeping quality of the product. The texture of the butter depends also on the glyceride composition of the milk fat. Many factors have been shown to alter the proportion of various fatty acids of which the milk fat is composed[31]. Variations in feeding are probably the most important ones, but the stage of lactation, the age of the cow and the weather conditions have also been shown to be involved. However, the available evidence[31] on the influence of the two latter factors is not very convincing.

Cox and McDowall[33] have shown that the properties of New Zealand butterfats follow seasonal trends which are different from those of other countries and, furthermore, that the inter-relationship between some of the properties are unexpected and poorly understood. It seems obvious that further critical investigations on the composition of New Zealand butterfats are required.

Only four sets of suitable twins were available when an opportunity occurred to test the efficiency of monozygotic twins on the milk fat composition. They were two-year-old heifers which had been reared together on a high plane of nutrition. Seven of the eight heifers calved within a period of a fortnight while the eighth calved six weeks later than the first calving heifer. The between-set differences in calving dates were not significantly greater than the within-set differences. After calving, the odd numbered members of each set were rotationally grazed while their mates were set-stocked. McMeekan[34] has shown that these two contrasting systems of grassland management, if practised for a whole lactation or longer, result in considerable production differences. However, in the peak period of the pasture growth (October-December) the differences in production are not great, especially in well grown first calving heifers. The quality of the grass at this time of the year is also very similar under the two systems. The butterfat productions of the two groups of animals over the fortnight the trial lasted are shown below:—

	Rotational Group lb/day/cow	*Set Stocked Group lb/day/cow*
1st Fortnight	1.02	1.10
2nd Fortnight	1.02	1.06

Three samples of milk were taken from each cow at weekly intervals at the end of November and beginning of December. Each sample was examined separately by Dr. F. H. McDowall of the New Zealand Dairy Research Institute, to whom the author is grateful for the permission to publish the results. The following characteristics were determined:

(1) Reichert-Meissl value
(2) Iodine value
(3) Softening point
(4) Saponification value.

Reichert-Meissl values, Iodine values, saponification values for the milk fats were determined by the British Standard Method[35]. Softening points were measured by Barnicoat's modification of the falling-ball method[36].

(1) *Reichert-Meissl Value*

The Reichert-Meissl value indicates the extent to which the lower or volatile fatty acids are present. It is expressed as the number of cubic centimeters of 0.1N. Alkali necessary to neutralize the volatile acids in 5 g of fat. There are indications that pasture feeding tends to decrease the Reichert-Meissl value[31]. The results of the examination are shown in Fig. 16. It can be seen that the twins show a fairly good concordance. The average within-set difference was only 0.37, while the range between the highest and lowest testing sets was relatively great, viz. 2.74.

The analysis of variance is presented in Table XV.

TABLE XV. ANALYSIS OF VARIANCE: Reichert-Meissl Values

Source of Variation	df	ss	ms	Significance
Between sets	3	23.1	7.7	SS
Within sets	4	1.3	0.3	NS
Between days	2	0.1	0.1	NS
Sets x days	6	2.8	0.5	NS
Residue	8	5.4	0.7	
Total	23	32.7		

Of the total variation, 60 per cent was due to inter-set differences while the remainder could be described to residual effects. The fairly high twin-efficiency value of 11 indicates that monozygotic twins are far superior to random animals in investigations of factors affecting the Reichert-Meissl value of the milk fat.

(2) *Iodine Value*

The percentage of iodine which is absorbed by a fat is known as its iodine value. It is a measure of the proportion of unsaturated fatty acids, which, in milk fat, mainly consist of oleic acid. Pasture-fed cows tend to produce a milk fat of high iodine value. Cox and McDowall[31], however, have shown that under New Zealand conditions there is a very pronounced decline in the iodine values in mid-summer, i.e. at the stage of the season when maximum values are reported in countries of the Northern Hemisphere.

The results of the estimations are shown in Fig. 17. It can be seen that while the range of values obtained between sets is relatively great or 5.5, the within-set differences are also wide, amounting, on an average, to 1.5.

The analysis of variance is presented in Table XVI.

TABLE XVI. ANALYSIS OF VARIANCE: Iodine Values

Source of Variation	df	ss	ms	Significance
Between sets	3	108.4	36.1	S
Within sets	4	16.0	4.0	SS
Between days	2	5.6	2.8	SS
Sets x days	6	2.9	0.5	NS
Residue	8	2.1	0.3	
Total	23	135.0		

The differences between sets were significant while the differences within sets and also between sampling days were strongly significant. These three sources of variation amounted to 70, 16 and 7 per cent respectively, of the total variance. It seems, thus, that the main source of variation in the iodine values over a fortnightly period in mid-season is mainly due to genetical factors. Consistent individual differences, not due to inheritance, are also fairly important, and may depend on the degree the animals draw on their body fat deposits. In this connection it must be pointed out that the within-set differences were not due to differences in treatment (in this case, rotational grazing versus set stocking). This is shown by the fact that two of the set stocked animals showed higher iodine values than their rotationally grazed co-twins, while the remainder, on the other hand, showed lower values than their mates. The variations due to sampling days may have been due to either a progressive change in the pasture growth, to the prevailing weather conditions, to the advancing stage of lactation, or to a combination of any of these factors.

The twin efficiency value was calculated as 4, which indicates that monozygotic twins can be used with advantage in work involving the iodine-value of milk fat.

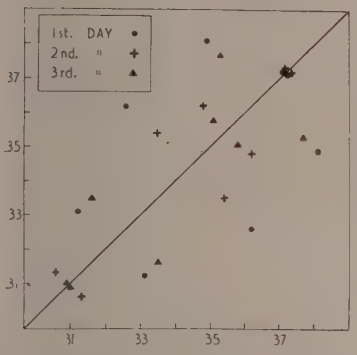

FIG. 17.—The iodine values of butterfat; 4 sets.

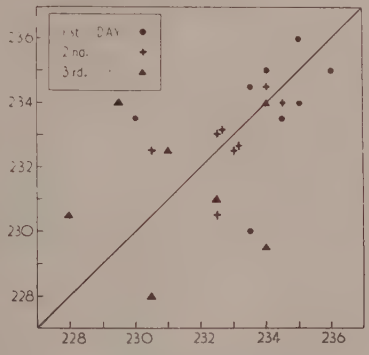

FIG. 18.—The saponification values of butterfat; 4 sets.

(3) *Saponification Value*

This value is equivalent to the number of mg KOH required to saponify one gram of fat. In milk fats there is generally a strong correlation between this value and the Reichert-Meissl value, but it has been shown[33] that the saponification value of New Zealand butterfat continues to rise for two months after the Reichert-Meissl value has reached the peak and has begun to fall.

The results of the present investigations are shown in Fig. 18. It can be seen that the twins show a fairly poor concordance. The average within-set difference was 1.5 while the range between sets was as small as 3.2. The analysis of variance is shown in Table XVII.

TABLE XVII. ANALYSIS OF VARIANCE: Saponification Values

Source of Variation	df	ss	ms	Significance
Between sets	3	35.3	11.8	SS
Within sets	4	20.4	5.1	SS
Between days	2	19.4	9.7	S
Days x sets	6	6.4	1.1	S
Residue	8	2.2	0.3	
Total	23	83.9		

The between-set differences, although highly significant, amounted to only 18 per cent of the total variation, while the within-set differences amounted to 30 per cent. It is not likely that the treatments caused the within-set differences, as two of the rotationally grazed heifers showed higher, and the two others showed lower values than their set-stocked co-twins. The possible causes for the significant differences between sampling days have already been discussed in connection with the iodine values. These differences amounted to 35 per cent of the total variation. The significant days x set interaction for the saponification values indicates that sets of twins, because of their specific genotypes react differentially to different environmental conditions. The interaction term accounted for 10 per cent of the total variation. The calculated twin efficiency value was less than unity.

(4) *Softening Point*

Pasture feeding tends to lower the softening (or melting) point of butterfat[7]. The effects of various environmental factors on the interrelationship between the softening point and iodine values are obscure and need clarification.[35]

Fig. 19 shows that the softening points of the twins' milk fat were highly concordant. The range between highest and lowest testing sets was relatively great or 2.53 when compared with the average within-set difference of 0.38. The analysis of variance is presented in Table XVIII.

TABLE XVIII. ANALYSIS OF VARIANCE: Softening Points

Source of Variation	df	ss	ms	Significance
Between sets	3	22.0	7.3	SS
Within sets	4	1.6	0.4	NS
Between days	2	13.6	6.8	SS
Days x sets	6	1.1	0.2	NS
Residue	8	2.5	0.3	
Total	23	40.8		

The highly significant between-set differences which accounted for 39 per cent of the total variation indicate that the genotype of a dairy cow is an important factor in the determination of the softening point of the milk fat. However, the differences between sampling days were also highly significant and accounted for 48 per cent of the total variation; this indicates that type of food, weather or stage of lactation over a very short span of time can materially alter the softening points.

The calculation of the twin-efficiency value resulted in the fairly high figure of 9.

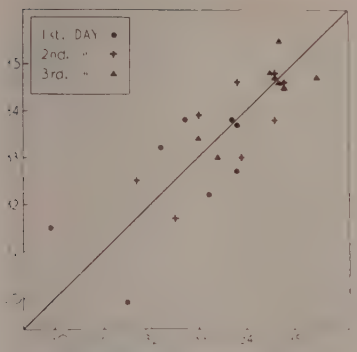

FIG. 19.—The softening points of butterfat; 4 sets.

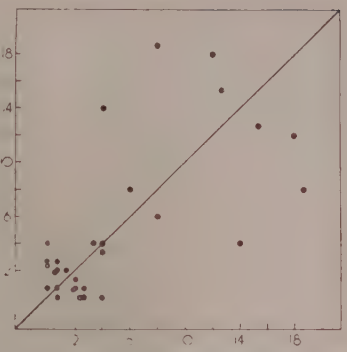

FIG. 20.—The 2-days average faecal egg counts (egg/g); 16 sets.

E. *Faecal Egg-counts*

Parasitic infestation is an important source of stock losses under pastoral conditions, especially in growing animals. Although a great mass of data have been obtained on the influence of various external factors on the worm burden in grazing animals, no information seems to be available on the importance of the individuality of an animal as a factor causing variation in worm infestation.

The following trial with monozygotic twins was carried out to discover whether inherent individuality influenced the number of worm eggs voided in the faeces.

Faeces samples were collected from sixteen 9-months old sets of heifer twins on two days separated by a six weeks interval. The egg counts were made according to the method of Hunziker *et al.*[37] by Mr. L. Whitten of Wallaceville Animal Research Station. The results are shown in Fig. 20. It can be seen that there was a recognisable concordance which was also shown by the small average within-set difference of 60 egg/g as compared with the difference of 360 egg/g between the two extreme sets.

The analysis of variance is presented in Table XIX.

TABLE XIX. ANALYSIS OF VARIANCE: Faecal Egg Count

Source of Variation	df	ss	ms	Significance
Between sets	15	821	54.7	S
Within sets	16	143	8.9	NS
Between days	1	90	90.3	S
Days x sets	15	292	19.5	S
Residue	16	106	6.6	
Total	63	1452		

The between-set differences accounted for 33 per cent of the total variance while the within-set differences accounted for only 5 per cent. The egg counts were significantly greater on the second sampling day, but of the total variance only 9 per cent was due to this factor, while the day x set interaction was important, accounting for 26 per cent. It

is, however, likely that a great part of this latter variation was caused by the fact that the parasites went through a phase of self-accelerating growth in the time interval between the first and the second sampling days. Thus, the egg counts of the twins which showed low initial values increased only a little (measured in absolute terms) when compared with the egg counts of the twins showing high initial values.

The twin efficiency value was calculated as $2\frac{1}{2}$.

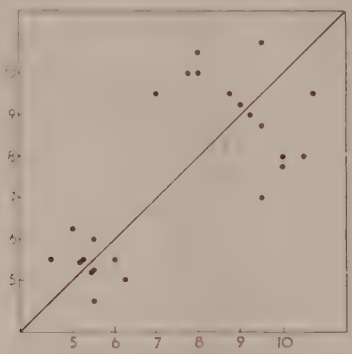

FIG. 21.—The 4-days average blood titre response to *Br. abortus* vaccination (coded); 12 sets.

F. *Response to Vaccination* (Br. abortus, *Strain 19*)

In the course of routine vaccination against *Br. abortus*, opportunity was taken to investigate the agglutinin response of monozygotic twins. Thirteen sets of twins, all practically of the same age ($5\frac{1}{2}$ months at the first vaccination), were vaccinated twice at three months interval; 5 ml of a standard vaccine (Strain 19) were given subcutaneously. The vaccine was prepared by Mr. M. Buddle of Wallaceville Animal Research Station, who also measured the blood-titre responses. Blood samples for examination were obtained twice at irregular intervals after each vaccination.

The average titre-values (coded) for the four samplings are shown in the scattergram in Fig. 21.

The average within-set difference of 1.2 units (code) was relatively small when compared with the differences of 5.2 units shown between the two sets giving greatest and smallest response.

The analysis of variance is shown in Table XX.

TABLE XX. ANALYSIS OF VARIANCE: Agglutinin titres (*Br. Abortus* Strain 19)

Source of Variation	df	ss	ms	Significance
Between sets	11	323.9	29.4	S
Within sets	12	63.4	5.3	NS
Between days	3	1412.9	471.0	SS
Days x sets	33	380.2	11.5	SS
Residue	36	125.1	3.5	
Total	95	2305.5		

The variance due to sampling days accounted for the greatest part of the total variation. The great differences between days was caused by the fact that the interval between the first vaccination and the subsequent sampling days was relatively long compared with the interval between the second vaccination and the subsequent sampling days. In the first case the sampling thus coincided with regressing titres, while in the second case the titres had reached their peak at the time of sampling. For these reasons it is not profitable to discuss the relative influence of the various sources of variation on the total variance.

The significant between-set differences indicate that genetical factors are important in the determination of serological response to bacterial infection. An examination of the data revealed that it was not possible to predict from the result of one sampling whether a set of twins was going to show, relative to the other sets, a high or low titre at the following sampling. The highly significant days x sets term can therefore be thought to measure a real environment-inheritance interaction.

The twin efficiency value was caculated as 2¼.

DISCUSSION AND CONCLUSIONS

With the reservations contained in the introductory note in mind, the analysis of the material presented in this paper indicates that the usefulness of monozygotic twins for experimental work varies according to the characteristics in consideration. The highly significant between-set differences shown to occur indicate that the expression of most of the characteristics depend to a measurable extent on genetic factors. The generally small and insignificant within-set differences on the other hand show that "acquired" individuality is an unimportant source of variation.

A final general finding worth stressing is the significant day x set term found in the majority of the time repeated trials. Only by the study of monozygotic twins has it thus been possible to assess the magnitude of the environment-inheritance interaction.

It seems that the gain of this general knowledge has justified the time and effort spent on the uniformity trials. Furthermore, a strong case can be made out for future more extensive research of similar type. A recurring impediment to many classes of cattle research has been the dearth of an exact knowledge of what may be termed normal values or the normal range of many characteristics. Monozygotic twins could be employed very usefully in the compilation of such data. The type of experiment visualised involves the measurement of all important characteristics, at regular age intervals on a fair number of monozygotic twins born within a short compass of time, and reared together. By analysing the variation obtained in the measured characteristics, it would be possible to assess the part played by inheritance, age, season, interaction between inheritance and age or season, and by not easily controllable environmental factors. If, in addition, an equal sample of fraternal twins could be observed simultaneously, the result could be interpreted with still greater accuracy, especially in gauging the importance of inherited factors as causes of variation.

ACKNOWLEDGMENTS

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The author is indebted to Dr. C. P. McMeekan, Superintendent of Ruakura Animal Research Station for advice and helpful criticism.

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A COMPARISON OF BREEDS OF RAM FOR FAT-LAMB PRODUCTION

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Summary

A comparison of the influence of breed of sire upon fat lamb production has been made over a period of four years. The sires used were Corriedale, Southdown, Ryeland, South-Suffolk, Border Leicester, Dorset Horn and Suffolk on Corriedale ewes, and Romney, Southdown and Border Leicester on Romney ewes. Attention has been focussed particularly upon comparison with the Southdown. The conclusions reached are as follows:—

(1) With the exception of the pure bred lambs, all the crosses gave essentially similar percentages of milk lambs drafted fat off the mothers.

(2) The growth rates of the lambs by the heavy sires, Border Leicester, Dorset Horn and Suffolk, were greater than those of Southdown cross lambs by approximately 0.09 lb live weight gain per day.

(3) The carcass weights of the lambs by the Border Leicester, Dorset Horn and Suffolk rams were approximately 4 lb heavier than the Southdown cross lambs both as milk lambs and as rape lambs. The lambs by Ryeland and South-Suffolk rams occupied an intermediate position.

(4) There were no differences in commercial grading of the carcasses though those by the Southdown were undoubtedly superior in regard to blockiness and shortness of leg.

Introduction

In New Zealand, as in most countries, crossbreeding is a most important aspect of fat-lamb production. Ewes are supplied as cull or surplus breeding stock from the more extensive grazing areas of unimproved hill country, while rams are supplied from stud flocks of the distinctive mutton type breeds. As far as the breed of ewe in New Zealand is concerned, the North Island contains virtually only one—the Romney, while in the South Island there is considerable variation from a preponderance of fine-woolled halfbreds and Corriedales in the Canterbury district to an exclusively Romney flock in Southland.

Of the sires used for fat-lamb production, the Southdown occupies a dominant position. It is almost the only sire used in the North Island, while in the South about 80 per cent of the sires are Southdown. The remaining 20 per cent of rams are of the heavier breeds—notably the Border Leicester, but also includes Ryeland, Suffolk, Dorset Horn, English Leicester and crossbred rams such as Southdown x Border Leicester and Southdown x Suffolk (known as South-Suffolk). These rams are used mainly in districts where feed is grown for fattening lambs after weaning. Historically, the original sires of the "Canterbury lamb" were Border Leicester, English Leicester and Shropshire, but these have now largely been replaced until the situation is as already explained. The supremacy of the Southdown has arisen in the main from two distinct characteristics of Southdown-cross lambs, namely, the high percentage of lambs which can be drafted fat off the ewes (the so-called milk lambs), and their excellent conformation which enables them to be drafted fat at light carcass weights of the order of 28-36 lb.

These considerations, together with the fact that the selective London market before the war demanded the lightweight carcass and that a price schedule greatly favouring this carcass operated, were responsible for the Southdown rising to undisputed supremacy.

After the war, the authors were afforded the opportunity of carrying out field trials to determine the relative characteristics of the different crosses for producing fat lambs. New Zealand is the only country in the world in which the Southdown is regarded so highly, and there is the danger ever present in any monopolistic situation that the virtues of other breeds may be neglected or suppressed.

Without going into detail, it can be said that the three characteristics upon which fat lamb crosses are and will continue to be judged are as follows:—

(i) percentage drafted fat off the mothers;
(ii) carcass weight;
(iii) carcass conformation or grading.

Comparisons between different crosses must therefore be considered in terms of these features.

With the exception of similar trials carried out at the Animal Research Station, Ruakura, concurrently with our own, no controlled experiments had been conducted in New Zealand on fat-lamb crosses since the turn of the century. It was felt therefore that a study of this subject was overdue. Trials now to be described were carried out over four years, 1947-50 inclusive. The results of the first two years' work have already been described very briefly,[1] as have also the results of the Ruakura work[2] which was carried out during 1946-48. It is proposed here to give a detailed analysis of all the results obtained in our own experiments. These fall into two categories, viz. those carried out for two years 1947-48 at Kirwee, and those over the remaining two years at Ashley Dene.

Experimental Methods

The techniques used were the same in all trials. An even line of ewes was randomised on a live-weight basis into groups of 60, with each of which two rams of the appropriate breed were placed for mating. Two rams were employed as an insurance against ram infertility, and also to extend the range of genotype tested. After mating, the various groups of 60 ewes were assembled into one mob and thereafter run together until the conclusion of the trial. The ewes were identified by eartag and all lambs were tagged at birth. Weighings of all sheep were made at approximately monthly intervals. Records of all ewe and lamb deaths were kept.

The lambs were sent to the works in two drafts—the first draft consisting of milk lambs fat off the mothers, and the second draft, the weaned lambs off rape. The time of drafting was determined by the feed supply and thrift of the lambs as in commercial practice. On the day of drafting the milk lambs, all the ewes and lambs were first weighed (weaning weight), following which the lamb buyer drafted the "fats" in the normal manner. An experienced lamb buyer was employed for the purpose with instructions not to take many "seconds," and to be as impartial as possible with the different crosses. It will be seen that this was a very difficult task for him, even though it was possible to give him the live weight of each lamb. On the following day when the lambs were killed at the freezing works, individual carcass weight, grades and measurements were obtained.

It should be remembered that in the North Island fat lambs are graded "Down Cross" "Prime Crossbred" and "Seconds", whereas in the South Island the first two grades are amalgamated into one grade, "Prime", with "Seconds" as in the North Island. In certain cases in the following tables a column entitled "Theoretical Drafting Percentage" has been included. This is the percentage which would have been drafted on the objectively determined weaning weight alone, on the assumption that Southdown-cross lambs must reach 65 lb live weight to grade prime, Romney and Corriedale 70 lb and Border Leicester cross 75 lb. An analysis of data over the years shows this to be approximately correct and to be in many cases a better guide to drafting percentage than that obtained in practice by subjective methods.

The undrafted lambs were weaned and fattened on rape. When all the rape was eaten the lambs were killed in one final draft. Out of 350-500 lambs in each trial there was never more than half a dozen unfit to be killed in this draft.

The term "drafting percentage" represents the percentage of milk lambs drafted, based on the total number alive at drafting. Unless otherwise stated, it includes both prime and second grade carcassed lambs. The "percentage of seconds" is the percentage of second grade carcasses in any draft and is therefore based on the number of lambs drafted. In certain cases in the following tables the second grade lambs have been eliminated and the drafting percentages expressed as "percentage of primes drafted." This is based on the proportion of prime carcassed lambs to the total number of lambs alive at drafting.

In the graph showing rate of growth of the lambs, the mean live weight of the groups has been corrected for age (maximum correction 2 lb) and for disproportionate sex ratio (maximum correction 0.7 lb).

Statistical analyses of growth rates up to weaning have been made. In the absence of any reliable data on birth weights of the different crosses, no birth weight correction has been made and growth rate has been taken as weaning weight divided by age at weaning. It is appreciated that this is not the true growth rate. The weaning-weight/age figures were subjected to analysis of variance followed by the "t" test for significance. The weaning weights were in all cases corrected for sex by the method of equating cell means. As in the first three years there were very few twins the statistical analysis was applied to singles only. In 1950, when approximately equal numbers of singles and twins were born, the weaning weights were corrected for both sex and multiple birth, again by equating cell means.

DETAILS AND RESULTS OF FATTENING TRIALS

Kirwee Trials, 1947 and 1948

The trials were conducted on the Kirwee Experimental Farm, a typical Canterbury arable, fat-lamb farm, situated approximately in the centre of the Canterbury Plains on light-medium soil. The design of the trials was as follows:—

Each year 180 aged sound-mouthed Romney ewes were randomized into 3 groups of 60 and mated to Romney, Southdown, and Border Leicester rams. 180 aged sound-mouthed Corriedale ewes were similarly divided and mated to Corriedale, Southdown and Border Leicester rams.

After mating, the ewes were run as one flock, but before lambing each group of 60 was divided in half, one half being kept on good pasture (High plane), the other, on poor pasture (Low plane) for purposes of comparison and to supply sufficient store lambs for the weaning trials on rape. With the exception of one Southdown ram, each year, all rams were from the College stud.

1947 Trial: The ewes used were 5-year Romney and 6-year Corriedale. The rams were put out on 25 March. The ewes were wintered on pasture, chou moellier and turnips, and after lambing were carried on pasture alone.

The High Plane lambs were drafted on 22 December, 1947 at a mean age of 122 days, the Low Plane on 5 January, 1948. The weaned, undrafted lambs from both lots were carried on rape until 25 February, 1948. The mean live weights of the ewes were as follows:—

> May—Romney 130 lb, Corriedale 120 lb; August (just before lambing began)—Romney 143 lb, Corriedale 134 lb; December weaning weight (without fleece)—Romney HP 137 lb, Romney LP 121 lb, Corriedale HP 129 lb, Corriedale LP 111 lb.

Individual group weight differences due to breed of sire were small. Fleece weights throughout the four years were of the order 8-10 lb, so that a correction to ewe weaning weights may be made if desired.

The season was generally a favourable one with a rainfall of 31 in. The spring was early and the feed supply good until November and December, when hot dry conditions prevailed, causing a rapid hardening and drying of the pasture. As a result of the summer being dry and hot, the rape was rather stunted and parched, but the weaned lambs fattened surprisingly well.

The growth curves of the single lambs are given in Fig. 1.

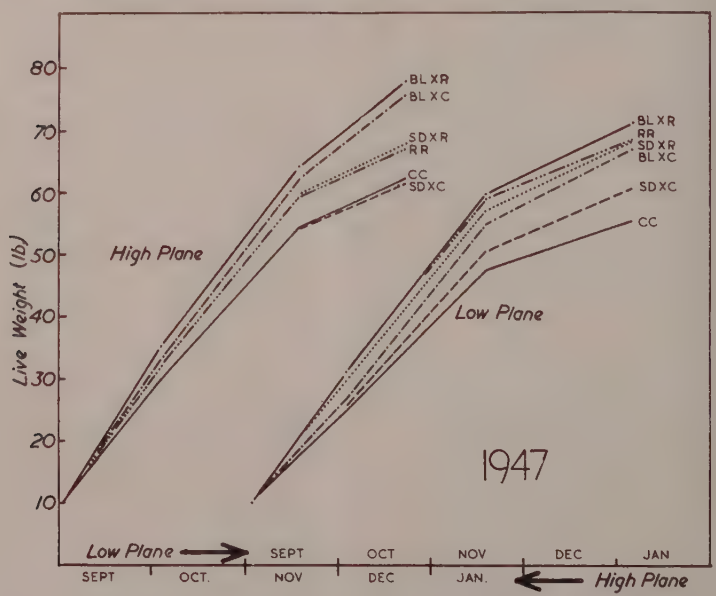

FIG. 1.—Mean growth curves of single lambs, 1947 (corrected for age and sex ratio).

The average number of single lambs per group was 18. The growth curves of the twin lambs have not been shown, as there were on average only 9 twins per group. The corrected weaning weights of these twins nevertheless follow the same order as the singles in regard to breed differences. Due allowance must be made for the small numbers of both singles and twins in interpreting the data.

Statistical analysis of the daily live-weight gain to weaning of the single lambs has given the following results:—

(1) In the High Plane groups, the differences between the Border Leicester on the one hand and the Southdown and pure breeds on the other are highly significant (< 1 per cent) for both Romney and Corriedale ewes. All differences between the Southdown and the pure breeds are not significant.

(2) In the Low Plane groups, the difference BL x C – C x C is highly significant, BL x R – SD x R and BL x C – SD x C are significant while all other differences are not significant.

The drafting and carcass data are given in Table I.

TABLE I. DRAFTING AND CARCASS DATA FOR LAMBS, 1947

Breed of lamb Ram × Ewe	MILK LAMBS					RAPE LAMBS		
	HP Singles Only				LP Singles	Singles & twins		
	% Drafted	Mean Carcass wt. Primes & Seconds (lb)	% "Seconds"	Theoretical Drafting Percentage	% Primes Drafted	Initial live wt. (lb)	Mean live wt. gain (lb)	Mean Carcass wt. (lb)
R x R	40	33.4	14	35	15	57.3	24.6	36.3
SD x R	70	35.4	7	65	40	58.8	21.9	37.9
BL x R	62	38.8	0	80	50	65.2	27.3	41.5
C x C	33	35.3	0	35	10	56.8	23.0	36.1
SD x C	33	33.6	0	42	25	55.6	21.7	35.1
BL x C	78	38.2	21	67	15	60.4	25.4	38.6

Note: The percentage of "seconds" in the rape lambs was 12% with no significant differences between groups. Group numbers of rape lambs varied from 18 to 30.

The following observations can be made on the data in the table:—

(i) The Border cross gave, on average, a higher drafting percentage than the Southdown, whether determined as the actual or the theoretical percentage.

(ii) The carcass weights of the Border cross lambs were nearly 4 lb heavier than the Southdown cross lambs.

It should be remembered that a high percentage of second-grade lambs in the first draft, e.g., BL x C, not only reduces mean carcass weight of that draft but also reduces the weight of the same cross in the rape lambs, since if these second grade lambs were not taken they would be the heaviest of the weaned lambs.

1948 Trial: The design of this trial was an exact replica of the previous one, though entirely new sets of both ewes and rams were used. The Romney and Corriedale ewes were bought-in 5-year-old ewes.

The rams went out on 2 April. The ewes were wintered on old pasture, turnips and hay. There was a shortage of feed on the farm as a result of the dry autumn. Throughout the winter, the ewes were on a level of feeding below maintenance, since from mating to lambing they lost weight. After lambing, the High Plane ewes were transferred to a newly established pasture of perennial and short rotation ryegrasses and clovers, while the Low Plane ewes were heavily stocked on an old pasture. Drafting was done on 6 January 1949 at a mean age of 122 days. The weaned lambs were grazed on rape until 25 February 1949, when the final draft was taken.

The mean live weights of the ewes were as follows:—

May, Romney—116 lb; Corriedale—98 lb; August (just prior to lambing), Romney—115 lb; Corriedale—95 lb; January weaning weight (without fleece), Romney HP—132 lb; Romney LP—99 lb; Corriedale HP—105 lb; Corriedale LP, 89 lb.

The growth curves of the single lambs are given in Fig. 2.

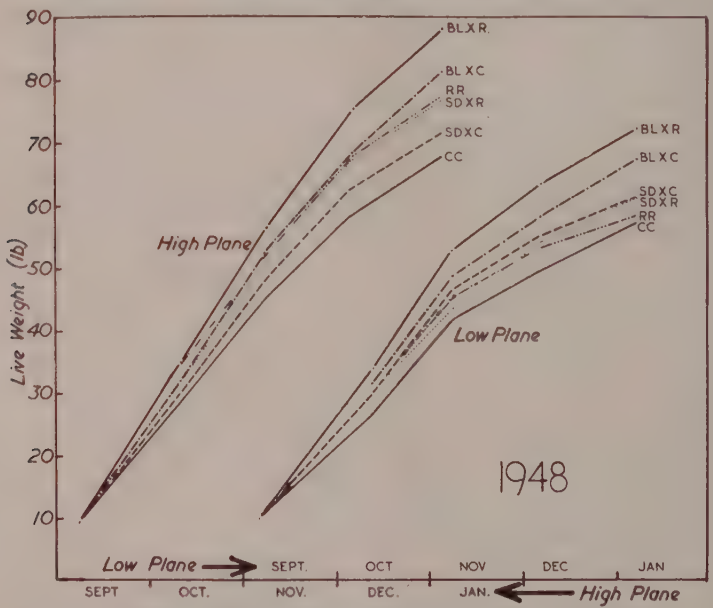

FIG. 2.—Mean growth curves of single lambs, 1948 (corrected for age and sex ratio).

Numbers varied from 16-22 with an average of 20 lambs. The growth data of twin lambs has not been considered. Amongst the Corriedales there were scarcely any twins, while in the Romneys there was an average of only 9 twin lambs per group. These nevertheless agreed with the usual observation that the weaning weight of Border cross twins was 5-10 lb greater than those of either Southdown cross or pure Romney. The growth rates of the different groups have not been analysed statistically. By analogy with the 1947 analysis, in which the numbers and differences were similar, it is clear that the increased growth rate produced by the Border Leicester would be statistically highly significant, whereas the differences produced by the Southdown would not be significant with the possible exception of the Low Plane SD x C – C x C difference.

TABLE II. DRAFTING AND CARCASS DATA FOR LAMBS, 1948

Breed of lamb Ram x Ewe	MILK LAMBS					RAPE LAMBS		
	HP Singles				LP Singles	Singles & twins		
	% Drafted	Mean Carcass wt. Primes (lb)	% "Seconds"	Theoretical Drafting Percentage	% Primes Drafted	Initial live wt. (lb)	Mean live wt. gain (lb)	Mean Carcass wt. (lb)
R x R	83	37.5	7	78	0	56.3	25.0	35.8
SD x R	100	37.1	0	100	40	53.0	24.0	35.9
BL x R	100	41.4	5	95	35	62.4	25.9	40.5
C x C	60	34.0	33	43	10	55.9	21.8	35.2
SD x C	90	35.7	5	85	40	53.9	21.4	35.3
BL x C	74	39.9	0	75	15	60.4	25.5	38.9

Note: The numbers of rape lambs per group varied from 22 to 35, and when killed there were less than 10 per cent of second grade carcasses.

The drafting and carcass data are given in Table II.

The following observations may be made on data presented in Table II:—

(i) It will be seen both from the growth curves and from the percentage drafted, that the lambs grew extraordinarily well this season, in spite of the fact that the ewes had suffered fairly severe treatment during the winter.

(ii) On drafting percentage the Southdown was on average slightly (5-10 per cent) better than the Border Leicester. Had it been necessary to draft earlier, for instance at the weighing on 6 December 1948, the theoretical drafting percentage is calculated to be still in favour of the Southdown to the extent of 10 per cent.

(iii) Border-cross carcass weights were again 4 lb heavier than Southdown cross, both in milk lambs and rape lambs. Similar carcass weight differences occurred in the LP singles drafted, though the numbers were small.

Ashley Dene Trials, 1949 and 1950

In 1949, the experimental work was transferred from Kirwee to Ashley Dene, a farm situated on light land seven miles west of Lincoln College.

The only ewes available on the farm were predominantly Corriedale, so that in both years the trials were restricted to this breed of ewe. In actual fact some Romney rams had been used in the Ashley Dene flock, so that the line of ewes employed would vary in breeding from Romney x Corriedale to pure Corriedale. Different sets of rams were used each year in the trials. The Corriedale, Border Leicester and half of the Southdown rams were from the College studs. After mating, all the ewes were run in one large mob throughout the whole of the experiment. There was no subdivision into High and Low planes as at Kirwee, and the ewes were managed as in normal commercial practice. The two years offered great diversity of climate and season, 1949 being one of the driest, and 1950 one of the wettest on record.

1949 Trial: 360 Corriedale ewes were mated in groups of 60 to Corriedale, Southdown, Ryeland, Border Leicester, Dorset Horn and Suffolk rams. In each group there were 40 two-tooth and 20 four-tooth ewes. They were fed on very bare pasture (owing to the exceptionally dry conditions) plus hay and silage during tupping, and were wintered on sparse pasture supplemented with turnips and oat-sheaf chaff. After lambing, they were rotated round various pastures, mainly of perennial ryegrass and subclover. Owing to an abnormally dry spring and summer, the lambs were drafted on 5 December before shearing, at a mean age of 100 days. The undrafted lambs were weaned on to rape which lasted until the New Year when they were put on lucerne and finally drafted on 19 January, after 45 days on supplementary feed.

The mean live weights of the ewes were as follows:—

May, after mating—108 lb; mid-July—114 lb; December, at weaning (with fleece)—129 lb.

1949 was a year of extreme dryness. The 30-year average rainfall at Ashley Dene is of the order 24-26 in.; in 1948 the rainfall was only 18.21 in., so that 1949 was entered with very bare pastures, an insufficiency of hay reserves, and very poor turnips and greenfeed. Reduction of the number of ewes from 1700 to 1100, and purchase of some hay and chaff, made it possible for the sheep to be carried in reasonable condition. In 1949, the rainfall was also exceptionally low, viz. 18.25 in., and this aggravated the already poor position. The spring in particular was dry, and although this favoured the lambing, the grass grew for only six weeks before it was dessicated by hot dry weather in October and November. As a result, the lambs were drafted very early, on 5 December. Nevertheless, both the lambs and the ewes thrived remarkably well.

The growth curves of the lambs are given in Fig. 3.

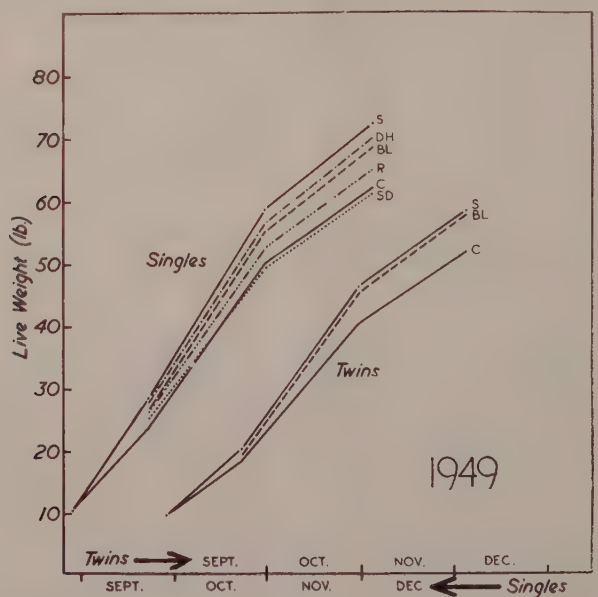

FIG. 3.—Mean growth curves of single lambs, 1949 (corrected for age and sex ratio).

The numbers of single lambs varied from 29 to 42 and of twins from 6 to 27. In Fig. 3 the growth curves of only those crosses which had 15 or more twin lambs are included. Unfortunately the Southdown group contained the least number of twins. These curves have been corrected for age and disproportionate sex ratio.

The growth rates or mean daily live weight gains of the different groups have not been analysed statistically. However, by analogy with the 1950 groups which were analysed thoroughly, it is considered that differences of over 3 lb in corrected weaning weight would be highly significant. It is obvious from this fact that the differences between the heavy sires—Suffolk, Dorset Horn and Border Leicester—on the one hand, and the Southdown and pure Corriedale on the other, are probably highly significant.

The drafting and carcass data are given in Table III.

TABLE III. DRAFTING AND CARCASS DATA FOR LAMBS, 1949

Sire	MILK LAMBS					RAPE LAMBS		
	Singles Only					Singles and twins		
	% Drafted	% Seconds	Carcass wt. Primes & Seconds (lb)	% Primes Drafted	Carcass wt. Primes only (lb)	Initial live wt. (lb)	Live wt. gain (lb)	Carcass wt. (lb)
C	53	47	30.8	30	32.6	53.9	19.6	34.0
SD	55	6	31.6	52	31.9	52.1	17.8	32.6
R	71	3	32.5	69	32.5	51.5	19.0	33.8
BL	82	30	34.0	57	35.7	57.9	23.5	37.1
DH	80	16	35.0	67	35.5	52.9	20.6	34.3
S	74	19	37.5	60	38.7	56.6	21.9	35.3

In interpreting Table III the following additional points should be noted:—

(i) Mean ages of singles at weaning were as follows: C, 100; SD, 99; R, 98; BL, 101; DH, 97; S, 103 days.

(ii) In view of the small numbers of twins in some groups and also of the very variable ages between twin groups, the drafting data has been confined to singles only. It can be said, however, that of what twins there were, the Southdowns occupy the same position relative to the other breeds as they do in the singles.

(iii) If the drafting percentage of prime lambs from the heavy sires is reduced to the same as from the Southdown (52 per cent) the corresponding carcass weights would be: R, 34.0; BL, 36.3; DH, 36.6; S, 39.6.

(iv) The percentages of second grade carcasses in the rape lambs were: C, 8; SD, 8; R, 5; BL, 10; DH, 13; S, 20.

The following conclusions are drawn from the data in the Table:—

(1) The drafting percentage of the heavy sires is considerably higher than that of the Southdowns. Making allowance for second grade lambs, the percentage of primes drafted is approximately 10 per cent higher than that for the Southdown.

(2) The carcass weights of the lambs by the heavy sires are considerably greater than those of the lambs by the Southdown. Considering the weights of the prime lambs only, the Border Leicester, Dorset Horn and Suffolk exceed the Southdown by 3.6-6.8 lb. If correction for percentage drafted is made, as suggested in Note (iii) above, these differences are increased and the Ryeland becomes significantly (2.1 lb) higher than the Southdown.

(3) The weight advantage of the heavy sires in the rape lambs is 1.7-4.5 lb. This advantage would have been greater still had there not been a higher drafting percentage and more second-grade lambs taken from those by the heavy sires. Moreover, the heavy sires had more twins, a fact which tended to reduce the mean weights of the rape lambs.

1950 Trial: 420 Corriedale ewes, mainly 6-tooth, were divided into seven groups of 60 ewes, for mating to Corriedale, Southdown, Ryeland, Border Leicester, Dorset Horn, Suffolk and South-Suffolk rams. The ewes, except for the addition of 80 to make a new group and to accommodate last year's mortality, were the same as used in 1949. The groups were also approximately the same except that they were in every case changed around; for instance, the 1949 Southdown group became the 1950 Border Leicester group and vice versa.

The rams were put out on 7 March, just as an excellent autumn flush of feed was commencing. The ewes were fed well throughout the winter on pasture and lucerne hay, and were lambed onto good saved pasture, phalaris and subclover dominant. Thereafter, they were rotated round several paddocks containing an abundance of growth—mainly perennial ryegrass and subclover. Owing to the abundance of feed the ewes were shorn in November and drafting and weaning postponed until the 27 December, at a mean age of the lambs of 132 days.

The undrafted lambs were weaned on 27 December and carried on various pastures, having a spell of 3 weeks on a paddock of rape, oats and turnips. They were all drafted to the freezing works on 29 March 1951 after a period of 13 weeks.

The mean live weights of the ewes were as follows:—

February, before mating—115 lb; April, after mating—134 lb; August, immediately before lambing began—165 lb; September, after lambing 138 lb; December, at weaning (without fleece) - 136 lb.

1950 was a season of ample rainfall and excellent pasture growth. The total rainfall was 30 in. Early autumn rains brought away an exceptionally good flush of autumn feed. Thereafter, rainfall was well distributed, favouring pasture growth and ensuring good crops of turnips and greenfeed. The winter was not severe, but the spring and summer were cool and moist. Not until early December did pastures dry out. In late December and throughout January, February and March, when the weaned lambs were fattening, exceptionally heavy rainfall occurred, 22 in. in four months; this was no doubt partly responsible for the slow rate of fattening during the period.

The growth curves of the lambs, corrected for age and sex ratio are given in Fig. 4. There was an exceptionally high lambing percentage (130) and a high number of twins this year. The number of singles varied from 25 to 32 and of twins from 29 to 55.

Statistical analyses of the mean daily weight gains to weaning (132 days), and also to the mid-November weighing (88 days) have been made. These analyses combined both singles and twins. The results obtained are as follows:—

(i) *Weaning*: The differences between the Suffolk, Dorset Horn, Border Leicester and Ryeland are not significant, nor are those between the South Suffolk, Southdown and Corriedale. All four of the first group are however highly significantly greater than all those of the latter group.

(ii) *To 88 days*: The only modification of the above conclusion required is that the Dorset Horn now becomes significantly greater than both the Border Leicester and Ryeland.

The drafting and carcass data are given in Table IV.

TABLE IV. DRAFTING AND CARCASS DATA FOR LAMBS, 1950

Sire	MILK LAMBS				RAPE LAMBS		
	Singles		Twins		Singles and twins		
	% Primes Drafted	Carcass wt. Primes (lb)	% Primes Drafted	Carcass wt. Primes (lb)	Initial live wt. (lb)	Live wt. gain (lb)	Carcass wt. Primes and Seconds (lb)
C	46	37.2	28	33.7	62.2	19.2	36.5
SD	76	37.4	35	33.8	58.3	18.4	35.6
R	66	40.1	50	36.5	64.0	20.1	38.4
BL	82	40.1	28	35.2	64.3	20.5	38.2
DH	76	40.5	54	38.2	66.4	22.5	40.7
S	78	41.5	20	35.0	67.9	22.4	40.2
S-S	100	37.7	24	34.1	58.6	19.0	36.1

In interpreting Table IV the following additional points should be noted:—

(i) Mean age of singles varied from 131 to 134 days and of twins from 128 to 132 days. In the singles the Southdown group and the heavy sire groups had the same ages.

(ii) If the drafting percentage of South-Suffolk singles were reduced to the same as the Southdown, carcass weight would increase from 37.7 to 39.0 lb. Equating drafting percentage in the twins would raise the Southdown weight to 34.7 lb in comparison with the South-Suffolk.

(iii) The percentage of second grade lambs taken in the milk lambs was approximately 10 per cent in both singles and twins.

(iv) In the twin lambs the Southdown group was 4 days older than the mean of the heavy sires. If an age correction were made it would reduce the percentage of Southdown primes drafted and would reduce their carcass weight by 1 lb, or increase the mean carcass weight advantage of the heavy sires from 2.3 to 3.3 lb.

The following conclusions are drawn from the data in Table IV:—

(1) The drafting percentages of the heavy sires are in general equal to those of the Southdown.

(2) The carcass weights of the lambs by the Border Leicester, Dorset Horn and Suffolk rams are approximately 4 lb heavier in the singles, 3 lb heavier in the twins and 4 lb heavier in the rape lambs than those by the Southdown.

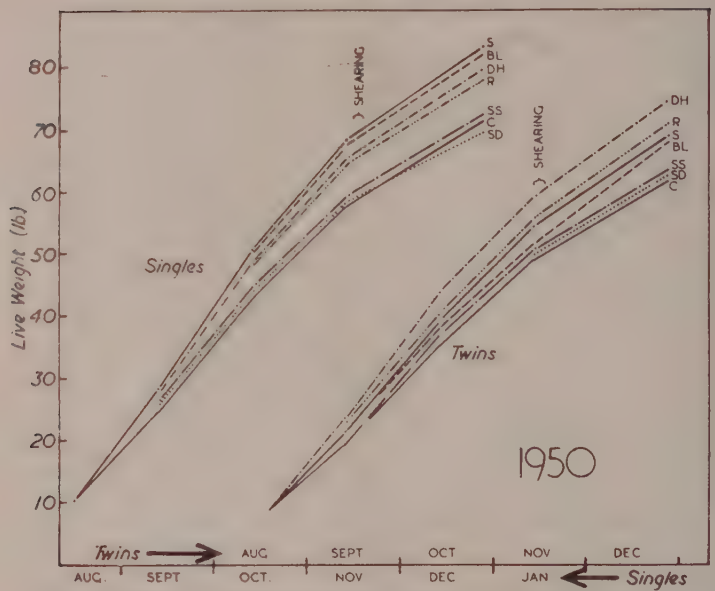

FIG. 4.—Mean growth curves of single lambs, 1950 (corrected for age and sex ratio).

MORTALITY OF EWES AND LAMBS

Records of all ewe and lamb losses, including lambs born dead or dying before tagging, were kept. The analysis is expressed in terms of percentage of ewes dying as a result of lambing, and percentage of all lambs dead or dying before weaning to total lambs born dead or alive.

Kirwee, 1947 and 1948

In order to obtain sufficient ewes and lambs upon which to base conclusions, all records of the two years at Kirwee have been collected under three headings—Pure Breeds (R x R, C x C), Southdowns (SD x R, SD x C) and Border Leicesters (BL x R, BL x C). There were approximately 240 ewes and 280 lambs in each of these categories.

The percentages of ewes dying were: Pure Breeds, $3\frac{1}{2}$; SD, 2; BL, 3. The only indication of an increased mortality was in the pure Romneys which had in both years the highest loss of any group. The percentages of lambs lost were: Pure Breeds, 22; SD, 22; BL, 13.

From the data there is no evidence of the Border Leicester causing an increase in ewe and lamb mortality. If anything, the reverse is true as far as lamb losses are concerned, though the significance of this is open to doubt in view of the small numbers involved.

Ashley Dene, 1949 and 1950

Even when the two years' results are combined, there were only about 120 ewes and 130 lambs per sire group. The ewe mortality at lambing was 4 per cent in the Southdown group and ranged from 3 to 6 per cent in the others. The lamb mortality was 18 per cent in the Southdown group and ranged from 11 to 17 per cent in the other groups.

There is again no evidence of the heavy sires causing an increase in ewe or lamb mortality; in fact, there is again some evidence of doubtful significance that they may actually reduce lamb losses.

BARRENNESS

Though the small numbers of sheep used make the analysis of dubious value, the efficacy of the different sires may be gauged from the percentage of barren ewes. Over all four years the barrenness was 13 per cent in Southdown groups and 9 per cent in all others combined. This at least confirms the opinion formed from observation that the Southdown was much less active and agile than the other breeds.

CARCASSES CONFORMATION AND DIMENSIONS

The dimensions of all carcasses were measured in terms of the characteristics used by Palsson[3] and Walker and McMeekan[4].

M length of the cannon-bone (left foreleg);

L length of carcass from symphysis pubis to the anterior edge of the middle of the first rib;

F length of leg;

G width of gigots;

T length of tibia plus tarsus.

A summary of these measurements is given in Table V. In the analysis of the data, singles and twins have been considered together, but second grade carcasses have been eliminated. The mean carcass weights will therefore not be identical with those of Tables I-IV. Table V gives the mean weight and measurements of all prime lambs (approximately 1400 in number) irrespective of sex and twinning.

These figures show that the lambs by the heavy sires (BL, DH and S), together with the pure bred lambs are longer and wider than the Southdown-cross lambs in all the characteristics measured, while those by the Ryeland and South-Suffolk are intermediate and approximate to those of the Southdown.

The ratio G/F has been used at this College[5] over a number of years as an index of conformation, a high ratio indicating a blocky carcass with short leg. From the mass of figures in Table V, the G/F column gives the best indication of inter-breed conformation differences. It is immediately apparent that the Southdown is outstanding and clearly superior to the heavy sires, with the Ryeland again approximating to the Southdown. The comparison of milk versus rape lambs in regard to G/F shows no consistent trend in 1947 and 1948, but a definite increase in G/F in the 1949 rape lambs.

As the increased carcass dimensions are partly due to weight differences, an alternative to using the G/F ratio for comparing inter-breed conformation is to make some carcass weight correction. Since as a rough approximation weight varies as volume, which varies as the cube of linear dimensions, the measurements in Table V could be reduced to correspond with a carcass of the same weight as the Southdown by dividing by the cube root of the relative weight. For example, comparing the Border Leicester with the Southdown:

$$\text{Corrected BL length} = \text{actual BL length} \times \sqrt[3]{\frac{\text{SD weight}}{\text{BL weight.}}}$$

If these corrections are made, reducing the figures to correspond to the weight of the SD milk lambs and expressing the figures as the percentage increase over the SD, the figures quoted in Table VI are obtained.

TABLE V. CARCASS WEIGHT AND MEASUREMENTS OF LAMBS, 1947-50

MILK LAMBS									RAPE LAMBS						
Year	Cross	Wt (lb)	Carcass Measurements						Wt (lb)	Carcass Measurements					
			M (mm)	L (mm)	F (mm)	G (mm)	T (mm)	G/F		M (mm)	L (mm)	F (mm)	G (mm)	T (mm)	G/F
1947 & 1948	R x R	36.2	110	586	249	224	188	90	37.1	116	576	255	224	192	88
	SD x R	35.2	110	567	242	225	183	93	36.9	109	557	240	227	182	95
	BL x R	39.4	119	606	274	231	202	85	41.1	119	596	267	234	204	88
	C x C	34.0	117	571	255	221	195	87	36.5	120	573	265	220	199	83
	SD x C	35.0	109	565	234	222	182	95	35.9	109	559	242	221	184	91
	BL x C	38.1	117	603	269	226	200	84	39.9	120	589	269	231	203	86
1949	C x C	32.3	111	553	250	207	185	83	34.3	-	560	250	225	183	90
	SD x C	32.0	103	535	222	203	170	91	32.7	-	540	228	224	175	98
	Ry x C	32.5	108	525	232	205	170	88	34.0	-	542	240	226	180	94
	BL x C	35.4	118	570	258	214	188	83	37.8	-	585	260	235	195	90
	DH x C	35.0	113	558	243	214	180	88	34.7	-	578	258	226	188	88
	S x C	36.9	114	568	250	217	185	87	37.3	-	585	263	239	195	91
1950	C x C	38.1		589	266	229	200	86							
	SD x C	36.6		559	240	224	183	93							
	R x C	38.3		580	250	229	190	92							
	BL x C	39.9		596	262	234	200	89							
	DH x C	39.9		591	261	234	197	89							
	S x C	41.6		601	267	237	203	89							
	S-S x C	36.7		565	251	225	191	90							

TABLE VI. PERCENTAGE INCREASE OVER SD-CROSS MILK LAMBS IN REGARD TO CARCASS DIMENSIONS CORRECTED FOR WEIGHT

Year	Cross	M	L	F	G	T	M	L	F	G	T
1947 & 1948	(R x R (L x C	4	2	6	0	5	6	-1	7	0	6
	(SD x R (SD x C	-	-	-	-	-	-2	-3	0	-1	0
	(BL x R (BL x C	5	3	10	-1	6	5	0	7	1	6
1949	C	8	3	10	2	8		2	7	4	1
	SD	0	0	0	0	0		0	0	6	1
	R	5	-1	4	0	0		-1	4	6	2
	BL	11	4	6	1	6		3	9	6	6
	DH	7	1	5	2	2		3	11	5	5
	S	6	1	6	2	3		3	10	7	6
1950	C		3	8	0	7					
	SD		-	-	-	-					
	R		2	2	1	1					
	BL		3	6	1	5					
	DH		2	6	1	4					
	S		2	5	1	5					
	S-S		1	4	0	4					

From this table, the superiority of the Southdown in regard to carcass conformation is again obvious. Body length and leg length of the Southdown cross lambs are smaller than those of the other breeds by 4-11 per cent (average, 7 per cent) for cannon bone length M; by –1 to + 4 per cent (av. + 2) for body length L; by 2-11 per cent (av. 7) for leg length F; by –2 to + 3 per cent (av. + 0.5) for gigot width G and by 0–8 per cent (av. 4) for T.

Of the breeds used, the Ryeland, and, to a lesser extent, the South-Suffolk approximate to the Southdown. The BL, DH and S fall into a group of their own, their M, L, F and T measurements being on average 8, 2, 6 and 4 per cent greater than the Southdown with only a 1.3 per cent increase in gigot width. Of these three sires, the measurements indicate that the DH and S are very similar indeed, and both slightly superior to the BL.

Comparison of the rape and milk lambs does not lead to any convincing conclusions. Amongst individual crosses, there are differences between milk and rape lambs, but these differences are neither consistent for the same cross in the different years nor consistent between the crosses. The general picture obtained from both the G/F ratios and Table VI is that the differences are not large, and moreover they are not consistent.

In this connection, our results disagree with some of those of Walker and McMeekan[4]. These authors analysed a large range of dimensions in Corriedale, Border Leicester x Corriedale, Southdown x Corriedale and Southdown x Romney lambs and analysed differences statistically.

While our figures for the general magnitude of dimensions in these crosses agree with those of Walker and McMeekan, disagreement arises over the more detailed analysis of comparative measurements, for instance, in rape versus milk lambs, light versus heavy lambs of the same breed, and even in some of the inter-breed comparisons. Although these authors showed statistical significance for their observations, our results have shown considerable variation even to complete reversal of relative measurements in different years. Walker and McMeekan do not state the number of lambs studied, and it is believed that the measurements were made on one set of lambs only. It is not proposed to list the points of disagreement since from a practical point of view they are of minor importance. Our results indicate that, while the main inter-breed differences show up every year, in the matter of detailed comparative studies, it would be unwise to draw conclusions on less than 3 - 4 years' work.

Discussion

Since the Southdown is unquestionably the premier fat lamb sire in New Zealand the results of the trials described will be discussed by comparing the other sires with the Southdown or what is equivalent, by using the Southdown-cross groups as the controls.

Rate of Growth

It is obvious from a study of Figs. 1 - 4 that there are large differences in growth rate due to the influence of the breed of sire, the larger and heavier sires producing consistently greater growth rates. Comparison of the pure bred lambs and the Southdown-cross shows that crossbreeding with the latter sire leads to very little, if any, increase in rate of growth. In three of the eleven possible comparisons the weaning weight of the Southdown-cross lambs exceeds that of the corresponding pure breed by 3 - 5 lb, but in the remainder, the growth curves are almost identical.

On the other hand, the three heaviest sires—Border Leicester, Dorset Horn and Suffolk—cause a marked increase in growth rate, which is consistent and significant over the whole period of growth from birth to weaning. There is little to choose between these three sires, for the lambs from all of them have weaning weights which are consistently about 10 lb greater than the Southdown. The Ryeland appears to fall into an intermediate position with a 4 - 8 lb weaning-weight advantage The South-Suffolk possibly occupies a similar position, slightly higher than the Southdown, though it would be unwise to decide this upon the results of one year's work only.

As far as growth rate is concerned, these sires fall into three distinct groups in order of merit:

(1) Border Leicester, Dorset Horn and Suffolk
(2) Ryeland (and possibly South Suffolk)
(3) Southdown, Corriedale and Romney.

The growth rates may be expressed as live-weight gain per day, measured as weight at any age less birth weight. For single lambs up to the weaning stage, viz. 100-130 days, growth rates in the three groups BL x C, SD x C and C x C, which were common for the four years, showed the following variations:

BL x C, 0.54 - 0.59; SD x C, 0.43 - 0.51; C x C, 0.40 - 0.52.

The corresponding daily weight gains to constant age of 90 days were:

BL x C, 0.60 - 0.65; SD x C, 0.51 - 0.59; C x C, 0.51 - 0.55.

Drafting Percentage

This is an extremely important factor in the consideration of fat lamb sires. Under New Zealand farm practice one of the overriding considerations is getting the lambs drafted fat off the mothers. This is necessitated by the decline in pasture growth and quality normally experienced in December or January, by the fact that the majority of farms (except in Canterbury) grow no supplementary lamb fattening feed, and those that do can fatten more lambs if a high percentage is drafted before the lambs are weaned onto feed. Unless a ram can give this high drafting percentage it is worthy of little consideration in the eyes of the New Zealand farmer. As already explained, the alleged high percentage given by the Southdown is one of the reasons for its ascendancy.

Examination of Tables I - IV in regard to drafting percentage leads to the following conclusions:

(1) In comparison with the pure breeds, the Southdown is responsible for a marked increase. For instance, in the single lambs over all trials the percentage of prime Southdown-cross lambs drafted has been nearly 70 per cent in comparison with 45 per cent for the pure breeds. A 20-30 per cent increase also occurred in the twins.

(2) The Southdown, however, does not show up so favourably when compared with other recognised fat lamb sires. Comparison with the Border Leicester over four years shows practically no consistent difference in percentage of prime lambs drafted. In 1949 and 1950, when other heavy sires were introduced, they also proved to be equally as good as the Southdown, the Dorset Horn being even slightly better.

If due allowance is made for the small numbers of sheep used, the broad general conclusion is that for producing lambs which can be drafted off the mothers in prime condition the Southdown is no better than any of the other recognised (i.e. excluding the Corriedale or Romney) fat lamb sires.

It might be argued that the lambs were drafted too late or at too great an age, thus not permitting the Southdown to express to the full its earlier maturity. The growth curves of the heavy sire crosses and the Southdown crosses are divergent and not parallel, and it is true that the 10 lb greater live weight at weaning of the lambs by the heavy sires would be reduced to say 8 lb if they had been weaned 3 - 4 weeks earlier. But examination of the growth curves shows nothing to indicate that this would alter, except to a very minor degree, the relative percentages drafted from the different groups. This is also borne out by calculating from the individual live weights the percentages which would have been drafted at the weighing prior (usually one month prior) to the actual weaning. In actual fact the seasons were taken as they came, and in one instance, viz. in 1949, the drafting was done at an exceptionally early date. Further, in every year the majority of other ewes on the two farms had been mated to Southdown rams and these mobs were invariably drafted within a week of these experimental sheep, sometimes before, sometimes after, so that there was no question of our having drafted late to the detriment of the Southdown.

Carcass Weight

There can be no doubt about the relative merits of the different sires on the score of carcass weight. Over the four years, the Border Leicester cross lambs were consistently 4 lb heavier than the Southdown cross. In the two years at Ashley Dene, the Suffolk and Dorset Horn crosses were likewise approximately 4 lb heavier. On present evidence it is not possible to distinguish between these three heavy rams as regards carcass weight of lambs sired.

The position of the Ryeland appears to be intermediate, with about a 2 lb advantage over the Southdown. The South-Suffolk is probably in a similar position, but further work is necessary on this breed. The carcass weights of Southdown-cross and pure Corriedale lambs are approximately equal.

Grading

Two features were noticeable with regard to drafting and grading. In the first place, the lamb buyer seldom drafted many second grade lambs from the Southdown groups but at times he took up to 30 per cent of "seconds" from the heavy sire groups (BL x C, 1947 and 1949). Secondly, the grader at the freezing works, a man of some 30 years' experience, was observed often to look twice at the carcasses by the heavy sires whereas he never hesitated with Southdown cross carcasses. These two observations serve to emphasize that drafting and grading are very subjective determinations.

However, the main point arising from the grading of the lambs was that the heavy sires had no difficulty in attaining the Prime grade, and as has already been pointed out, if the drafting percentages are determined as Primes only, the heavy sires are just as good as the Southdown.

As long, therefore, as only two grades—Prime and Second—are used, grading offers no disadvantage to the heavy sires. Where a special high quality grade is included, as in the North Island "Down Cross" grade, it is probable that the heavy sire carcasses would have difficulty in aspiring to this grade whereas the Southdown would not. Walker[2] has, in fact, shown this clearly in her analysis of the trials at Ruakura.

Carcass Conformation and Dimensions

It does not require a scientific investigation to prove the great superiority of the Southdown as a producer of the short blocky carcass —the type of conformation which helped to establish the reputation of that sire in pre-war days. Measurements have nevertheless been made, notably by Walker and McMeekan[4], to define in precise terms the dimensional characteristics of the different weights and grades of export lamb and also of some of the different breed crosses.

The subjective assessment of "quality" in fat lamb is probably based mainly on conformation, and to that extent the work of Palsson[3] and that of Walker and McMeekan has aimed at defining this in terms of objective measurements. In the present work, certain of the external measurements of the carcasses were made, but no account was taken of other important factors, notably fat cover and shoulder development. Nor have the authors, as has been done by Walker[2], determined the composition of carcasses of the different crosses in terms of bone, muscle and fat.

The present work indicates, however, that the crosses studied may be classified into three main groups, in order of merit as follows:—

(1) Southdown—outstanding for shortness and blockiness of carcass;

(2) Ryeland and South-Suffolk—occupying an intermediate position;

(3) Border Leicester, Dorset Horn and Suffolk—not very blocky and definitely rather long in the leg.

The order is the reverse of that for growth rate, weaning weight and carcass weight. The pure breeds, Romney and Corriedale, have a conformation which may occasionally be as good as the heavy sires but generally is inferior even to that class. Their growth rate and carcass weight is not superior to that of the Southdown cross.

It is apparent, therefore, that of the various crosses, i.e. excluding the pure breeds, conformation and carcass weight are inversely related. With the existing standards of the various sire breeds, increase in carcass weight through the use of heavy sires can be obtained only through some sacrifice in shortness and blockiness of carcass.

CONCLUSION

The trials described have shown that the use of the heavy sires, notably the Border Leicester, Dorset Horn and Suffolk, can in comparison with the Southdown, increase carcass weight by approximately 4 lb, without sacrifice in percentage of lambs drafted fat off the mothers, but with some sacrifice in shortness and blockiness of the resulting carcass. The Ryeland and, probably such crossbred rams as the South-Suffolk and Southdown x Border Leicester, occupy an intermediate position.

The repercussions of these observations on the fat lamb industry of New Zealand have been discussed elsewhere[1, 2, 6].

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GLASSHOUSE TESTS OF ORGANIC INSECTICIDES AGAINST APHIDS ON SWEDES

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Summary

(1) Nicotine sulphate and 13 newer organic insecticides were tested in the glasshouse for contact effect against *Brevicoryne brassicae* (L.) and/or *Myzus persicae* (Sulz.) on swedes.

(2) Contact action was assessed from the relative survival of aphids 24 hours after treatment and the insecticides were classified as "highly effective", "effective" or "ineffective."

The following treatments had highly effective contact effect against *B. brassicae*: Folidol (1 lb/100 gal); Thiophos (1 lb/100 gal); and Hexone (1 pt/100 gal).

The following were highly effective against *M. persicae*: Folidol (0.06-0.5 lb/100 gal); Thiophos (0.06-0.5 lb/100 gal); Midol T. 10 (0.06-0.5 lb/100 gal); Higam (0.06-0.5 lb/100 gal); EPN-300 (0.25-1 lb/100 gal); Nicotine sulphate (0.083-0.166 gal/100 gal); Midol 100 + oil (0.25-0.5 gal/100 gal); and Midol 100 (0.5 gal/100 gal).

(3) Phytocidal effects were observed with Arathane (3 lb/100 gal) and Dieldrin (2 lb/100 gal).

(4) Marked systemic or residual effect was observed with Pestox III. Lesser effect was observed with EPN-300, Thiophos and Higam.

Introduction

In recent years a number of new insecticides have been developed for which aphicidal properties have been claimed. Certain of these have been tested under glasshouse conditions for contact effect against the green peach aphid (*Myzus persicae* (Sulz.) and the cabbage aphid (*Brevicoryne brassicae* (L.)) on swedes.

Materials Used

Composition of the insecticides used is set out below.

Nicotine sulphate (40 per cent nicotine), a water miscible preparation.

EPN-300 (27 per cent ethyl p-nitrophenyl thionobenzene phosphonate), an emulsifiable preparation.

Pestox III (66 per cent bis dimethylamino phosphonous anhydride plus a wetting agent), a water miscible preparation.

Hexone (15 to 20 per cent tetraethylpyrophosphate), a water miscible preparation.

Folidol (22.4 per cent diethyl p-nitrophenyl thiophosphate), an emulsifiable preparation of parathion.

Thiophos (15 per cent diethyl p-nitrophenyl thiophosphate), a parathion wettable powder.

Aldrin (23 per cent 1, 2, 3, 4, 10, 10-hexachloro-1, 4, 4a, 5, 8, 8a hexahydro-1, 4, 5, 8-dimethano naphthalene), an emulsifiable preparation.

Dieldrin (24 per cent 1, 2, 3, 4, 10, 10-hexachloro-6, 7-epoxy-1, 4, 4a, 5, 6, 7, 8-octahydro-1, 4, 5, 8-dimethano naphthalene), an emulsifiable preparation.

Higam (25 per cent lindane, i.e. 99 per cent pure gamma isomer of benzene hexachloride), a wettable powder.

Arathane (25 per cent dinitro capryl phenyl crotonate), a wettable powder.

Aramite (15 per cent beta chloroethyl beta (p-tertiary butyl phenoxy) alpha-methylethyl sulphite), a wettable powder.

Midol T. 10, an emulsifiable preparation containing 2.7 per cent benzene hexachloride (0.7 per cent gamma isomer) plus 4 per cent azobenzene plus 0.3 per cent parathion.

Midol 100 + oil, an emulsifiable preparation containing 4 per cent azobenzene, 0.4 per cent rotenone, 2 per cent pyrethrum extract (10 per cent pyrethrum) and 5 per cent mineral oil.

Midol 100, an emulsifiable preparation containing the same ingredients as above without mineral oil.

EXPERIMENTAL METHODS

Swede plants of the variety Superlative, grown in 4-in pots, were infested with four apterous, viviparous aphids when in the two to four rough leaf stage. When the aphids had reproduced to give adequate numbers (usually about two weeks later), single leaves were marked and the numbers of aphids present were counted. Approximately 200 aphids were counted per plant. Insecticides were then applied within 24 hours, and a further 24 hours later records were taken of the number of live aphids present on marked leaves for estimation of contact effect. In some cases further counts were carried out on these leaves four to seven days later. Four single-plant replications were used for each treatment, and at least one set of four check plants was included in each trial.

In Trials I and II, insecticides were applied by a hand atomizer. In the other trials each group of four plants was placed on a revolving turntable and 200-250 ml. of spray were applied from a small power sprayer at 35 lb pressure per sq. in. In Trial V, 400 ml. of spray were used for each treatment.

Counts were subjected to statistical analysis and the insecticides were evaluated on a basis of relative numbers of survivors on treated plants. The log $(n + 1)$ transformation was used in analysis. Examinations were made 24 hours after treatment, and in order to compensate for initial differences in aphid numbers, the means of transformed values before treatment were subtracted from the means of the transformed values after treatment. When further counts were made, e.g., one week later, the transformed values of the results obtained 24 hours after treatment were subtracted from transformed values of the later figures to compensate for differences in survival due to mortality in the first 24 hours following application of insecticides. Thus, a plus sign in the mean log $(n + 1)$ column of the tables below means that there has been an increase in the aphid populations whereas a minus sign means that there has been a reduction.

RESULTS AND CONCLUSIONS

In Table I, III, IV, and V results of individual trials against *M. persicae* are recorded and in Table II results of tests in control of *B. brassicae* are given. Results may be combined by classifying each treatment into one of three categories.

Treatments placed in Category A were found to be highly effective. Treatments in Category B were significantly more effective than checks, while those in Category C were not significantly different in their efficacy from checks.

TABLE I. SPRAY TRIAL I AGAINST MYZUS PERSICAE ON SWEDES
(Table of Means)

Insecticide	Concentration in 100 gal. water	Mean number live aphids		Means log (n+1) 24 hr (b-a)
		Before treatment (a)	After 24 hr (b)	
Check		179.5	191.3	+0.01
Hexone	1 pt	179.3	24.0	-0.85
Pestox III	1 lb	180.3	19.8	-0.91
Thiophos	1 lb	195.8	36.3	-0.77
EPN-300	1 lb	222.5	1.5	-2.03
Arathane	3 lb	200.8	54.5	-0.57
Aramite	2 lb	174.8	92.5	-0.24
Aldrin	2 lb	202.5	32.3	-0.83
Dieldrin	2 lb	170.3	24.3	-0.87
Differences for significance at		5%		0.30
		1%		0.40

* = phytocidal damage.

TABLE II. SPRAY TRIAL II AGAINST BREVICORYNE BRASSICAE ON SWEDES
(Table of Means)

Insecticide	Concentration in 100 gal. water	Mean number live aphids				Means log (n+1) 24 hr (b-a)	Means log (n+1) 96 hr (c-b)	Means log (n+1) 168 hr (d-b)
		Before treatment (a)	After 24 hr (b)	After 96 hr (c)	After 168 hr (d)			
Check		106.3	180.0	367.0	609.3	+0.26	+0.39	+0.63
Hexone	1 pt	175.0	1.5	3.3	5.5	-1.91	+0.12	+0.43
Pestox III	1 lb	221.3	11.3	0	3.3	-1.22	-1.02	-0.59
Thiophos	1 lb	212.0	8.8	0	0.3	-1.57	-0.74	-0.67
EPN-200	1 lb	101.0	11.8	3.3	25.3	-0.95	-0.58	-0.01
Nicotine sulphate	0.166 gal	187.5	45.8	92.8	226.3	-0.77	+0.31	+0.66
Aramite	2 lb	152.3	176.8	378.5	822.3	+0.03	+0.39	+0.72
Aldrin	2 lb	236.8	216.3	185.8	417.0	-0.04	-0.17	+0.23
Dieldrin	2 lb	204.8	28.0	8.3	17.3	-0.87	-0.50	-0.17
Folidol	1 lb	105.8	0	0	0	-1.99	--	--
Differences at 5% for significance						0.56	0.44	0.58
						0.75	0.60	0.79

TABLE III. SPRAY TRIAL III AGAINST MYZUS PERSICAE ON SWEDES
(Table of Means)

Insecticide	Concentration in 100 gal. water	Mean number live aphids			Means log (n+1) 24 hr (b-a)	Means log (n+1) 168 hr (c-b)
		Before treatment (a)	After 24 hr (b)	After 168 hr (c)		
Check		144.0	211.8	602.8	+0.07	+0.49
EPN-300	0.5 lb	145.8	1.5	137.5	-1.93	+1.61
Pestox III	0.5 lb	143.5	20.3	174.0	-2.01	+1.13
Hexone	0.06 gal	148.8	0	321.5	-2.09	+1.66
Folidol	0.5 lb	145.8	0	0.3	-2.15	+0.07
Thiophos	0.5 lb	148.3	0	0	-2.09	0
Dieldrin	1 lb	145.8	16.5	60.0	-0.93	+0.77
Nicotine sulphate + soft soap	0.16 gal	148.5	0	34.0	-2.11	+0.92
Higam	0.5 lb	146.5	3.0	19.3	-1.65	+0.07
Midol T.10	0.5 gal	149.8	0	0	-2.15	0
Midol 100 + oil	0.5 gal	143.8	0	2.5	-2.09	0
Midol 100	0.5 gal	149.8	0.3	40.0	-2.05	+2.01
Differences for significance at 5%					0.43	1.09
1%					0.58	1.49

This classification may be summarized as follows for contact effect against *M. persicae*:

Category A:
Folidol (all concentrations tested).
Thiophos „ „
Midol T. 10 „ „
Higam „ „
EPN-300 (0.25 to 1 lb in 100 gal).
Nicotine sulphate (0.083 to 0.166 gal in 100 gal).
Midol 100 + oil (0.25 to 0.5 gal in 100 gal).
Midol (0.5 gal in 100 gal).

Category B:
Hexone (0.25 to 1 pt in 100 gal).
Aldrin (2 lb in 100 gal).
Dieldrin (0.5 to 2 lb in 100 gal).
Arathane (3 lb in 100 gal).
Midol 100 + oil (0.125 gal in 100 gal).
Midol 100 (0.25 gal in 100 gal).
Pestox III (0.25 to 1 lb in 100 gal).

Category C:
Nicotine sulphate (0.021 to 0.041 gal in 100 gal).
EPN-300 (0.06 lb in 100 gal).
Hexone (0.06 to 0.25 pt in 100 gal).
Dieldrin (0.125 to 0.25 lb in 100 gal).
Aramite (2 lb in 100 gal).
Midol 100 + oil (0.06 gal in 100 gal).
Midol 100 (0.06 to 0.125 lb in 100 gal).

TABLE IV. SPRAY TRIAL IV AGAINST MYZUS PERSICAE ON SWEDES
(Table of Means)

Insecticide	Concentration in 100 gal. water	Mean number live aphids		Means log (n+1) 24 hr (b-a)
		Before treatment (a)	After 24 hr (b)	
Check		280.0	396.7	+0.14
EPN-300	0.25 lb	261.0	2.3	-2.14
Pestox III	0.25 lb	276.3	0.5	-2.32
Hexone	0.031 gal.	283.0	0	-2.43
Folidol	0.25 lb	252.5	0	-2.38
Thiophos	0.25 lb	271.3	0	-2.43
Dieldrin	0.5 lb	250.5	0	-2.40
Higem	0.25 lb	266.0	1.5	-2.20
Midol T.10	0.25 gal.	279.5	0	-2.38
Midol 100 + oil	0.25 gal.	253.5	3.8	-2.11
Midol 100	0.25 gal.	296.3	7.0	-1.52
Differences for significance	at 5%			0.50
	1%			0.67

Similarly treatments may be summarized for contact effect against *B. brassicae* as follows:

Category A:
Folidol (1 lb in 100 gal).
Thiophos (1 lb in 100 gal).
Hexone (1 pt in 100 gal).
Category B:
Nicotine sulphate (0.166 gal in 100 gal).
Pestox III (1 lb in 100 gal).
Dieldrin (2 lb in 100 gal).

Category C:
Aldrin (2 lb in 100 gal).

The only treatments causing phytocidal damage were Arathane applied at 3 lb in 100 gal and Dieldrin at 2 lb in 100 gal.

The test methods used here may not necessarily demonstrate small differences in effectiveness between treatments. Waters (1943) indicated that enclosed cages should be avoided; individual leaves were, therefore, not caged, with the result that movement of aphids was not inhibited. This is apparent in some of the counts made 168 hours after treatment. The later counts must, therefore, be interpreted with caution. Waters also pointed out that the insecticide resistance of aphids varies considerably with sunlight intensity. In view of these and other variable factors, treatments have been classified into broad groups, and no attempt has been made to place the insecticides in order of merit within these groups. Despite these limitations it is believed that the differences at the 5 per cent level of significance within the tables gives an adequate representation of toxicity under the existing experimental conditions.

In some treatments it was found that aphid numbers continued to decrease 96 or even 168 hours after treatment. This is suggestive of a residual or systemic effect. Thus Table II shows that continued decrease

TABLE V. SPRAY TRIAL V AGAINST MYZUS PERSICAE ON SWEDES
(Table of Means)

Insecticide	Concentration in 100 gals water	Mean number live aphids			Means log (n+1) 24 hr (b-a)	Means log (n+1) 144 hr (c-b)
		Before treatment (a)	After 24 hr (b)	After 144 hr (c)		
Check		183.5	81.5	449.8	-0.37	+0.73
EPN-300	0.5 lb	185.3	18.5	275.5	-1.09	+1.17
" "	0.25 "	185.3	2.5	4.5	-1.84	-0.10
" "	0.125"	208.8	16.8	25.8	-1.14	-0.39
" "	0.07 "	211.3	66.5	275.0	-0.62	+0.58
Pestox III	0.5 lb	192.5	83.3	0.8	-0.53	-1.56
" "	0.25 "	185.3	65.3	8.8	-0.55	-0.77
" "	0.125"	187.8	190.8	146.5	-0.08	-0.27
" "	0.06 "	180.0	108.0	112.3	-0.35	+0.01
Hexone	284 ml	202.3	29.3	128.0	-1.43	+0.78
"	142 "	204.0	57.5	226.3	-1.51	+1.10
"	71 "	236.0	50.3	132.8	-0.81	+0.51
"	35.5 "	196.8	81.0	309.3	-0.43	+0.44
Folidol	0.5 lb	197.0	4.8	5.3	-1.81	+0.03
"	0.25 "	202.5	0	1.3	-2.30	+0.19
"	0.125"	213.0	0	0.5	-2.32	+0.15
"	0.60 "	207.0	0	26.0	-2.31	+0.77
Dieldrin	1 lb	190.3	7.0	6.3	-1.69	-0.17
"	0.5 "	194.0	51.8	45.0	-0.67	+0.01
"	0.25 "	212.0	118.3	278.5	-0.31	+0.20
"	0.125"	184.0	82.3	115.0	-0.45	+0.17
Nicotine sulphate	0.166 gal					
+ soft soap	5 lb	188.3	4.5	16.5	-1.68	+0.37
Nicotine sulphate	0.083 gal					
+ soft soap	5 lb	202.3	2.5	8.3	-1.91	+0.20
Nicotine sulphate	0.041 gal					
+ soft soap	5 lb	213.0	29.5	159.3	-0.99	+0.83
Nicotine sulphate	0.021 gal					
+ soft soap	5 lb	202.5	71.0	275.0	-0.46	+0.58
Higam	0.5 lb	194.3	0.3	1.8	-2.21	+0.15
"	0.25 "	190.8	3.5	0	-1.79	-0.49
"	0.125"	254.5	7.0	2.0	-1.84	-0.33
"	0.06 "	190.0	2.8	3.8	-1.79	-0.19
Midol T.10	0.5 gal	208.8	0	0	-2.32	0
" "	0.25 "	192.8	0	1.0	-2.28	+0.17
" "	0.125"	223.0	0	0	-2.35	0
" "	0.06 "	190.8	0	2.8	-2.28	+0.27
Midol 100 + oil	0.5 "	204.3	0.3	0.5	-2.23	+0.05
" " "	0.25 "	183.8	3.0	1.5	-1.82	-0.23
" " "	0.125"	203.0	27.0	32.5	-1.25	+0.33
" " "	0.06 "	208.8	11.0	41.0	-1.31	+0.58
Midol 100	0.5 gal	198.5	10.8	13.5	-1.67	+0.17
" "	0.25 "	184.8	8.8	8.8	-1.47	-0.08
" "	0.125"	219.8	44.0	140.5	-1.06	+0.65
" "	0.06 "	174.0	55.5	82.5	-0.69	+0.05
Check		214.3	148.3	290.8	-0.17	+0.29
Thiophos	0.5 lb	234.3	0.3	0.3	-2.29	0
"	0.25 "	224.8	1.3	0.5	-2.10	-0.13
"	0.125"	190.5	0	0	-2.27	0
"	0.06 "	213.5	0	0	-2.33	0
Differences for significance	5%				0.73	0.80
	1%				0.96	1.05

in numbers of *B. brassicae* was observed after 168 hours with Pestox III, Thiophos and EPN-300. A decrease was also observed after 96 hours with Aldrin and Dieldrin. There were no survivors after treatment with Folidol. Table III indicates that, although no continued decreases in numbers of *M. persicae* were observed 168 hours after treatment, no survivors were found with Thiophos, Midol T. 10 or Midol 100 + oil. With the same test insect, continued decreases were observed 144 hours after treatment with EPN-300 at 0.25 and 0.125 lb per 100 gal, Pestox III at 0.5, 0.25 and 0.125 lb per 100 gal, Dieldrin at 1 lb per 100 gal, Higam at 0.25, 0.125 and 0.06 lb per 100 gal, Midol 100 + oil at 0.25 lb per 100 gal, Midol 100 at 0.25 lb per 100 gal, and Thiophos at 0.25 lb per 100 gal, but not with EPN-300, Higam or Midol 100 + oil at 0.5 lb per 100 gal. (Table V.) The most outstanding decrease was with Pestox III at 0.5 lb per 100 gal, though this effect was not observed in Trial 3. Ripper, Greenslade and Hartley (1949) indicated the systemic effect of Pestox III, and gave evidence of its effectiveness against both *M. persicae* and *B. brassicae* in the field. Though Pestox III is not placed in the highest category for contact effect, the above data would suggest that it exerts a sustained effect over a period of at least one week when applied under the conditions given. Armstrong (1950) reported the outstanding residual acaricidal properties of EPN-300. These results indicate that this compound also possesses residual aphicidal properties. Sprays containing the chemically closely related parathion did not show a residual effect (with the exception of Thiophos on *B. brassicae*). However, such an effect could have been obscured by the high mortalities obtained with this insecticide. There is a voluminous literature concerning the aphicidal action and residual effects of benzene hexachloride, and these results indicate residual action, even at low concentrations, for at least one week after application.

Little is known of the residual effects of Aldrin and Dieldrin against aphids. With the Midols, complex mixtures of insecticides are being dealt with, and thus it is difficult to indicate which substances or substances are responsible for the apparent residual effect obtained in these experiments.

Acknowledgment

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MATERIALS SUITABLE FOR USE AS GRAFTING MASTICS

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Summary

Petroleum grease and petroleum wax emulsions to each of which hormones had been added, bituminous preparations, a proprietary latex, and grease impregnated linen tape, were all tested as graft sealing materials. Inclusion of 0.1 per cent indole acetic acid, 0.1 per cent indole butyric acid, or 0.1 per cent α- naphthalene acetic acid in grease increased callus growth, but not to the point where wounds 2 inch in diameter were covered in one season. Where 0.5 per cent α-naphthalene acetic acid was used scion growth was completely inhibited, though scions remained alive. Adding hormones to wax emulsions gave no improvement in performance. Bituminous compounds proved most satisfactory of the materials tested. There was no evidence of translocation of hormone from one leader to another.

Introduction

In an endeavour to find a suitable material for covering pruning wounds on fruit trees, several materials have been used which were thought to be of a consistency suitable for use as grafting mastics. A trial was carried out in a commercial orchard in Hawke's Bay on a fairly even block of 40-50-year-old Dougherty trees, which were being re-worked to the variety Granny Smith.

Experimental Procedure

The trees to be re-worked were cut back a few days before grafting, which was performed on 16 and 17 October, 1950. Experimental materials were applied to one leader on each of three adjacent trees, and two scions were pegged and tacked to each leader, except in one instance where three were applied because of its large diameter. One operator performed the grafting and applied the materials. The remaining leaders in the trees were grafted by the owner who used one grafting material throughout. Observations were made at intervals during the growing period. Finally, on 8 May, 1951, when growth for the season was almost completed, the total length of wood produced by each scion was measured.

In all but one instance where a material containing a hormone completely inhibited the growth of the scions, a commercially satisfactory "take" was obtained with all materials.

Average growth per scion for the experiment was 344 cm, and ranged from 153 to 530 cm. Trees producing growth at the lower end of the range would be satisfactory in practice. Except in a few instances, which will be discussed, there did not appear to be a definite correlation between the grafting material and the amount of scion growth to explain these large differences. Differences occurred both between scions on the same leader and between trees receiving similar treatments.

Materials tested

Mastics employed fell into the following groups:

(*a*) Hormone dressings based on green crude grease;
(*b*) Bitumastic compounds;
(*c*) Wax emulsions with and without hormones.

Two other materials were also used, a rubber latex and a grease-impregnated linen.

Group (a): Hormone dressings based on Shell grease Otina Compound "C"

Ether was used as a solvent for the hormone materials before inclusion in the grease.

Grease and the various materials incorporated provided a permanent cover over the leader-stubs, but moisture blisters caused lifting in places, although these did not burst and break the cover.

(1) *Grease alone*

Of the six grafts inserted, four grew well, one made very weak growth, and one failed. This failure was due to faulty insertion rather than to any damage due to the material. Bark of the leader was slightly damaged by the grease which melted and ran. This damage was not serious, but may become so, especially if the tissue becomes infected by fungi. No callus was formed round the perimeter or over the top of the stock-stub. (Fig. 1.)

FIG. 1.—Shell Otina Compound C. Showing grease running with slight damage on stock.

FIG. 2.—Shell Otina Compound C + 0.1 per cent α-naphthalene acetic acid. Note strong callus ring on stock and normal growth of scions.

Photos: J. W. Endt.

(2) *Grease + ether*

This mixture was tested to determine whether the ether had an effect on the graft. In all grafts the scions grew well and a ring of callus formed around the perimeter, but made no progress over the top of the stub. The fact that the dressing did not run would indicate that the inclusion of the ether is an improvement.

(3) *Grease + ether + 0.1 per cent Indole acetic acid*

Early in the growing season, there was some inhibition of growth of all the scions and this was reflected in their final growth. However, the growth could be considered satisfactory as it averaged 180 cm per scion. Massive, heavy, rough callus formed a ring all round the stock's perimeter and had commenced to grow over the top. The same lumpy callus had formed on the cut tip of each scion.

(4) *Grease + ether + 0.1 per cent Indole butyric acid*

This mixture proved satisfactory in every respect; its performance was similar to that of No. 3, without the disadvantage of scion growth being inhibited. Average growth was 400 cm per scion and these were some of the strongest produced in the trial.

(5) *Grease + ether + 0.1 per cent α-naphthalene acetic acid*

Behaved in a similar manner to No. 3. Inhibition of growth was not noticeable early in the season, but was reflected in the final growth, which averaged 153 cm. These were slightly shorter than scions on the same trees which did not receive hormone. Here again growth would have been considered satisfactory commercially (Fig. 2).

(6) *Grease + ether + 0.5 per cent + α-naphthalene acetic acid*

The increased concentration of hormone completely inhibited growth throughout the season. Callus over the stock and scion tips was the same massive, heavy, lumpy type produced by the other hormones. During the entire season the scions stayed green and plump indicating that they were still alive; in the middle of January the buds broke into a rosette of leaves but made no further progress (Figs. 3 and 4).

FIG. 3.—Shell Otina Compound C + 0.5 per cent α- naphthalene acetic acid. Note complete inhibition of growth of treated scions compared with the remainder of tree where the hormone was not used.

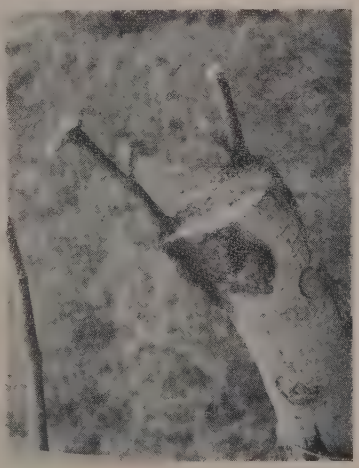

FIG. 4.—Close up of the same scions as in Fig. 3. Note the massive callus on scion tips.

Photos: J. W. Endt.

The material used on the other parts of each tree throughout the trial was M & B Grafting Wax. Scions sealed with this wax failed to show any of the heavy callusing on either stock stub or scion tips, indicating that there was no translocation of hormone from one part of the tree to another; hormones affected only the local areas to which they were applied.

It is also of interest to note that the inclusion of ether, and perhaps hormones, apparently prevented the grease from melting and running down the leaders and causing subsequent bark damage.

Group (b): Bitumastic Compounds

These were all proprietary bitumastic materials imported for experimental purposes from the U.S.A. where they are used in tree surgery.

(1) "Flintkote."
(2) "Daveykote."
(3) Barrett's Elastigum Roof Cement.
(4) Pecora Weatherite Plastic.
(5) "Treekote."

"Flintkote," which was used with the stock and scion illustrated in Fig. 5, is now available in commercial quantities in New Zealand.

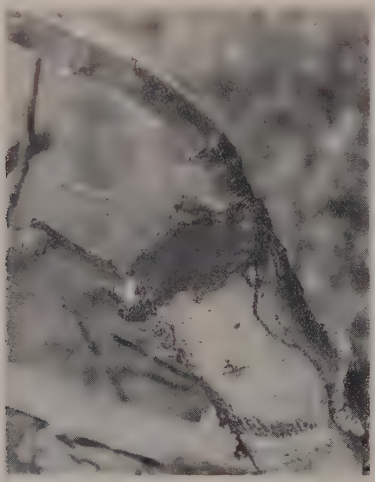

FIG. 5.—Flintkote—Bituminous material. Note the complete cover and the formation of callus without the cover disintegrating.
Photo: J. W. Endt.

All materials proved satisfactory. Scions protected by this type of dressing all averaged more than 400 cm, except those with "Daveykote" which averaged 320 cm. This latter, however, could be classed as satisfactory.

Hardening of the materials in all cases tended to be slow, which is an advantage in a grafting compound; it meant that all materials stretched instead of cracking when the scions swelled. It was also possible to mould the materials over any small cracks or holes some time after they had been applied. Finally they set hard, providing a

waterproof coat over the stock-stub, and also prevented the bark from cracking away from the wood in this area. This latter condition is often the cause of scions drying out and failing to "take," with subsequent die-back of the stock. Such cracks also provide places of entry for spores of fungous diseases, such as silver leaf.

Some moisture blisters formed underneath "Flintkote", "Daveykote" and Barrett's Elastigum Roofing Cement, but as none of these blisters broke there was no breach in the cover. No blisters formed beneath the other two materials. Callus round the perimeter of the stock was formed only where "Flintkote" was used. This was very slight and not comparable to the callus formed with the grease in Group (a).

Group (c): Wax emulsions

These were all wax emulsions, and except for "Ceremul W" they were of an experimental nature made up by the Vacuum Oil Company, each having a code number.

(1) E.F. 253W.
(2) E.F. 257W.
(3) E.F. 307W.
(4) E.F. 339W.
(5) E.F. 340W.
(6) E.F. 347W.
(7) "Ceremul W."

Manufacturers' Descriptions

E.F. 253W and E.F. 257W. Both products are an emulsion of a mixture of paraffin and microcrystalline waxes. They differ only in that E.F. 253W is softer, i.e. contains a smaller quantity of mineral silicate filler.

E.F. 307W is similar to E.F. 253W, except that it contains 1.3 per cent of Hortomone A. (Active ingredient: α-naphthalene acetic acid.)

E.F. 339W and E.F. 340W. Both products are an emulsion of microcrystalline wax with a melting point of 160°F., and contain the same quantity of mineral silicate filler. E.F. 339W differs from E.F. 340W in that it contains 500 mg. of the sodium salt of β-indole acetic acid per 1000 g. (.05 per cent.)

E.F. 347W. The same emulsified microcrystalline wax with a volatile type emulsifier. The percentage of wax is the same as in E.F. 339W and E.F. 340W, but the product contains no mineral silicate or any other filler.

Performance in the field

No. 2 was thicker in consistency than No. 1 but this difference did not make it any more difficult to apply. No. 3, which was supposed to be the same as No. 1, except for the hormone included, was very much thicker than either Nos. 1 or 2. Some difficulty was experienced in applying it to the grafts, but whether the inclusion of the hormone was responsible for this difference is not clear. Nos. 4, 5 and 6 were similar to each other in consistency and appeared thinner than No. 1.

Good "takes" of scions were obtained, but resulting growth was not so good as on trees where bitumastic materials were used. At the end of the growing season, Nos. 1 and 5 still protected the exposed wood on the stock stub, but had cracked round the perimeter between the bark and wood of the stock. This was the unsatisfactory feature of these dressings, especially as no callus formed at the junction of wood and bark to fill this gap.

The total lack of callus on all trees treated with these waxes indicated that they were not good carriers of hormones. Comparisons between these and the hormone-fortified grease dressings are not valid because of the lower concentrations used in these waxes. It is quite clear, however, that with waxes in their present form hormone fortification would be a waste of money. No. 6 was most unsatisfactory. Within a month it had peeled and flaked off badly (Fig. 6) so that by the end of the growing season the stock stub was unprotected. One scion failed, while growth of the other five averaged 162 cm, which was below average for the experiment.

FIG. 6.—E.F. 347W. Note complete disintegration of the dressing.

Photos: J. W. Endt.

FIG. 7.—Vultex—rubber latex. Note lack of callus, but the dressing has prevented separation of bark from the wood on the stock.

No. 7 behaved in a similar fashion to Nos. 1 to 5 of this group, with the added disadvantage that slight damage was caused to the bark of the stock. No callus was produced, the average growth per scion being 274 cm.

Of the remaining materials which could not be classified under the above heading, the rubber latex known as "Vultex", an American importation, was not of the consistency usual in grafting mastics, but because of its unique nature it was tried in this experiment. It was thin enough to apply with a brush but three coats had to be applied before it was thought that a complete seal of the scions had been made. Despite this, it did provide a permanent seal over the exposed stock stubs and prevented bark from separating from the wood. (Fig. 7). No callus was formed round the perimeter or over the stub, while some moisture blisters were found beneath it. A "take" was obtained with all six grafts, but their final growth was well below the best in the experiment. With "Denso", a grease-impregnated linen tape, which is primarily used for lagging metal pipes against corrosion, it was possible to bind the scions tightly to the stocks, without having to tack them in position. This material could be kneaded to take up any unevenness of the stock and

stretched without splitting when the scions swelled. In addition, it provided a permanent waterproof cover to the stocks during the entire season and showed no sign of peeling off. Some blisters filled with liquid formed under the dressing but did not break the cover. "Denso" has one disadvantage: it is tacky, causing grease to adhere to the operators' hands. The most efficient way to remove the grease is to wipe the hands with an absolutely dry cloth. The type of grease employed did not melt and run, or cause any damage to live tissue. No callus was formed round the perimeter beneath the dressing; in fact, at some points a gap was encountered between wood and bark of the stock. Growth of scions was only fair for the experiment, but would be satisfactory commercially.

DISCUSSION

Although fair-to-good results were obtained with all the materials used, except grease fortified with 0.5 per cent α-naphthalene acetic acid, some are obviously better than others. It might be argued that hormones included in bituminous compounds would give an almost perfect grafting mastic. But it has been found in other experiments that these hormones do not stimulate callus formation when applied in bituminous materials.

All the types of hormones employed in grease increased callus formation round the perimeter and to a limited extent over the top of the exposed stock. The greatest amount of callus was observed on the treatment with 0.1 per cent indole butyric acid. When the stocks to be grafted are 2 in. or more in diameter, as they were in this experiment, even this material did not give a complete callus over the exposed stock in one season. Doubts, therefore, arise as to whether the small amount of extra callus growth justified the cost of inclusion of the hormone

If hormones are to be used, this experiment has also shown that care should be taken to prevent any inhibition of scion growth either by the inclusion of unsuitable types of hormone or more especially by using them at too high a concentration. As at present, grease-based hormone grafting compounds are not obtainable commercially, results of this trial suggest that bituminous compounds are the most satisfactory grafting seals now available.

ACKNOWLEDGMENTS

The author wishes to express his sincere thanks to Mr. F. Meissner of Havelock North for his interest in this work and for making trees available for the trial; and to the Vacuum Oil Company for preparing the wax emulsions and providing information concerning them.

SODIUM ALGINATE AND CARBOXYMETHYL CELLULOSE AS SUBSTITUTES FOR ROTTED ORGANIC MATERIAL IN SOIL MIXTURES

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Summary

Sodium alginate (Manucol 2) and carboxymethyl cellulose (Cellofas B) were tested for their suitability to replace rotted organic material commonly used in soil mixtures for tomato plants. The work was done under glass during the winter and spring seasons of 1949 and 1950. Under the conditions of the experiments sodium alginate did not give results which would justify its use as a substitute for the organic material used. The possibility of substituting carboxymethyl cellulose for the organic material, up to the planting-out stage in flats and to maturity in pots, was indicated, provided that the normal fertiliser mixture was added.

Introduction

Quastel and Webley (1947) showed that the addition of sodium alginate to a soil improved its crumb stability and its water-holding power. They also noted that the incorporation into the soil of cellulose acetate, methyl cellulose or carboxymethyl cellulose improved its water-air relationship. Owen (1948), after discussing a stable manure and loam mixture which experience has shown to be suitable for propagating tomatoes, commented on the scarcity of stable manure and the difficulty of assessing the value of the various substitutes offered. He pointed out the advantages which would accrue from using sodium alginate to replace organic materials of uncertain composition. As it is a definite chemical entity, its use would make possible the recommendation of a standard soil mixture for the raising of tomatoes.

Since, in New Zealand, similar difficulties exist in obtaining a regular supply of a uniform sample of suitable organic material for seed and potting composts, the following experiments were conducted to test the possible value of sodium alginate and carboxymethyl cellulose under local conditions. The work was done during the winter and spring seasons (May to October) of 1949 and 1950.

Experimental Methods

Materials Used

The soil used in the experiments was from a rather heavy silt loam and had a pH of 7.4. The rotted organic material was prepared from spent hops and damaged baled hay broken down in a heap built on orthodox lines. During the formation of the heap, a nitrogenous fertiliser composed of dried blood and sulphate of ammonia was used, and a thin layer of soil was spread over each alternate six-inch layer of organic material. It was turned once in the course of the year allowed for it to be converted to a condition when it would pass through a half-inch screen with comparative ease. The loam and organic material were separately disinfected by steam before use, and when used together were

in the ratio of 7 : 3. The fertiliser was a mixture of dried blood, superphosphate and sulphate of potash giving an approximate analysis of 2.6 per cent nitrogen, 13 per cent phosphoric acid and 5.3 per cent potash; it was used at 0.5 per cent by weight of loam or loam mixture, being added after the latter had been disinfected by steam. The materials so far listed are those in general use at the Plant Diseases Division and found by experience to be suitable for the purpose. The sodium alginate (Manucol 2), and the carboxymethyl cellulose (Cellofas B), a light, finely fibrous, flocculated material, were obtained locally. The amount of each substance used was 1 per cent by weight of the loam or loam mixture and as with the fertiliser they were added after disinfection.

Tomatoes from one sample of seed of the variety Potentate were used in both seasons and were grown in seedboxes or flats which held 6 kg of soil, their inside dimensions being 16¼ in. x 10¾ in. x 2¼ in. The pots used during the second season are commercially known as "six-inch", holding 1.2 kg of soil.

1949 Season

Available greenhouse space limited the work to growing plants in flats, and to using the following treatments:

(1) Loam;
(2) „ + sodium alginate;
(3) „ + organic material;
(4) „ + fertilisers;
(5) „ + „ + sodium alginate;
(6) „ + „ + organic material.

Four flats, randomised over the available bench space, were used for each treatment; 200 seeds were sown in each flat, emergence was recorded and plants were progressively thinned to leave firstly 28, then 6, and finally 2 plants in each box. These were allowed to continue growth and carry one truss of fruit, the stem being topped two leaves above this point, and laterals removed as soon as practicable after they appeared. Weight of thinnings at each intermediate stage, and weight of fruit and total plant weight were recorded at the final harvest. As plants were cut at soil level, weight of roots is not included in the figures given.

Sowing date was 12 May, after which the temperature of the greenhouse was kept above 55°F., the average daily maximum during the period of germination being 79°F.

Emergence was recorded and first thinning completed on 3 June. The number of seedlings harvested at this period varied between treatments and flats, so that for uniformity the average weight of 100 seedlings from each box was recorded. At this stage of growth it was noted that plants grown with fertilisers and sodium alginate were pale and less vigorous than those in the other mixtures. At the next thinning on 24 June, however, this difference was not obvious. The final thinning, leaving two plants per flat was carried out on 6 July.

By 21 September as the space occupied by these plants was required for other work, it was found necessary to end the experiment. Only some of the fruit had commenced to colour, but it was noted that there was more colour in the alginate treatments than in the others. Results are given in Table I.

TABLE I. EMERGENCE AND SUBSEQUENT GROWTH OF TOMATOES IN DIFFERENT SOIL MIXTURES

Treatments	Emergence (%)	Average plant weight for 100 seedlings (g)	2* plants (g)	4 plants (g)	Av. total plant wt* (g)	Av. fruit wt. (g)
1. Loam	77	27.99	54.3	21.3	271	83
2. " + sodium alginate	71	25.51	63.1	25.8	277	73
3. " + organic material	82	30.80	73.9	29.2	362	123
4. " + fertilisers	80	27.99	80.0	38.1	495	241
5. " + fertilisers + sodium alginate	74	23.05	73.3	39.8	518	298
6. " + fertilisers + organic material	84	26.52	90.9	55.5	497	253
Difference required for significance at 5%	7.0	4.34	20.2	10.5	158	126
" " " " 1%	9.7	6.00	28.0	14.5	219	174

* Average weight of two plants plus fruit.

The tendency towards lower emergence in the alginate treatments was not significant. At the first thinning depression in growth induced by fertilisers and sodium alginate together was significant ($P = 0.05$) but was not significant by 24 June when the next record was taken. When total plant weight and yield of fruit are considered, no significant increase was obtained by the addition of sodium alginate or organic material to the loam used.

Treatments which included fertilisers gave equally good results at all stages subsequent to the first thinning (except for a temporary increase from the fertilisers and organic material combination at the stage when four plants were harvested), and it could be inferred that the loam used under the conditions of the experiment, if given fertilisers, did not require sodium alginate or organic material for improvement in plant weight or fruit production.

1950 Season

This year carboxymethyl cellulose was included in the treatments which were:

(1) Loam;
(2) ,, + sodium alginate;
(3) ,, + carboxymethyl cellulose;
(4) ,, + organic material;
(5) ,, + fertilisers;
(6) ,, + ,, + sodium alginate;
(7) ,, + ,, + carboxymethyl cellulose;
(8) ,, + ,, + organic material.

Growth of Plants in Flats

Each treatment consisted of four flats randomised over the eastern bench of a gabled greenhouse oriented north and south. The procedure was similar to that followed in 1949 except that the sowing date was later, 26 May, and all the fruit was allowed to colour, being harvested during the period 2-29 October. The date of picking, the number and the weight of the fruit were recorded for each treatment, and from the

figures obtained an index of the average date of ripening was calculated for each treatment by taking the sum of the individual dates of ripening and dividing by the number of fruit. For recording dates of ripening 30 September was called zero and succeeding days became one, two, three, etc. Results are given in Table II.

TABLE II. EMERGENCE AND SUBSEQUENT GROWTH AND RIPENING OF TOMATOES IN DIFFERENT SOIL MIXTURES (Plants grown in flats, 1950.)

Treatments	Emergence (%)	Average plant weight for 100 seedlings (g)	Average plant weight for 22 plants (g)	Average plant weight for 4 plants (g)	Av. total plant wt.* (g)	Av. fruit wt. (g)	Date of ripening index
1. Loam	55.1	18.64	43.5	58.8	697	469	23
2. " + sodium alginate	57.4	17.69	39.3	58.9	616	429	23
3. " + carboxymethyl cellulose	61.5	18.14	38.3	51.7	520	369	23
4. " + organic material	69.0	18.83	45.5	60.2	773	504	21
5. " + fertilisers	62.1	20.09	49.9	77.9	641	426	21
6. " + fertilisers + sodium alginate	42.6	16.82	51.1	94.3	691	488	19
7. " + fertilisers + carboxymethyl cellulose	51.3	18.74	56.5	93.5	743	497	20
8. " + fertilisers + organic material	50.5	17.38	57.0	98.1	783	502	19
Difference required for significance at 5%	5.9	2.27	10.9	17.9	161	139	4
" " " " 1%	8.1	3.08	14.8	24.4	218	188	6

* Average weight of two plants plus fruit.

Sodium alginate plus fertilisers gave a significant depression in emergence ($P = 0.01$), but in the absence of fertilisers this effect did not appear. When the weight of 100 seedlings was calculated, however, the depression in growth was not significant. As with the 1949 results, any depression due to the use of sodium alginate had disappeared by the time of the next recording.

At the time when 22 plants were weighed, there was no significant increase from the addition of any of the three test substances when used with loam alone. However, there was an increase ($P = 0.05$) when either carboxymethyl cellulose or organic material was combined with fertilisers.

When four plants were weighed the addition of fertilisers to loam gave an increase ($P. = 0.05$) over loam alone, but when the three test substances were added to this combination only the organic material gave an additional increase which was significant.

At the conclusion of the experiment there was no significant increase in total plant weight or yield of fruit from any treatment. However, there was a depression in total plant weight from the use of carboxymethyl cellulose without the addition of fertilisers ($P = 0.05$).

Growth of Plants in Pots

The trial was extended to observe the effect of the various soil mixtures on plants growing in pots. The seedlings for this work were raised in a standard loam, organic material, superphosphate and lime

mixture from seed sown on 16 May. On 30 May single seedlings were planted into six-inch pots filled with the eight loam mixtures given above. There were twelve pots in each treatment, randomised over the western bench of the greenhouse used for the flats. During October, fruit was harvested as it coloured, and at the final picking each plant was cut at soil level and its weight recorded.

Towards the end of the experiment it was noticed that the plants growing in pots showed signs of starvation well in advance of those plants growing in flats. The amount of soil available for the plants no doubt accounted for this, it being 1.2 kg in the case of the plants in pots as against 3 kg for those in flats.

Plant and fruit weights and index of ripening are presented in Table III.

TABLE III. EFFECT OF DIFFERENT SOIL MIXTURES ON GROWTH AND RIPENING OF TOMATOES (Plants grown in pots 1950)

Treatments	Av. total plant weight* (g)	Av. fruit weight (g)	Date of ripening index
1. Loam	182	119	22
2. " + sodium alginate	153	99	27
3. " + carboxymethyl cellulose	145	93	27
4. " + organic material	195	135	24
5. " + fertilisers	227	131	22
6. " + fertilisers + sodium alginate	225	145	23
7. " + fertilisers + carboxymethyl cellulose	291	199	20
8. " + fertilisers + organic material	264	172	20
Difference required for significance at 5%	33	32	3
" " " " " 1%	44	42	4

* Average weight per plant plus fruit

Carboxymethyl cellulose without the assistance of fertilisers again depressed growth, as shown by the figures for total plant weight ($P = 0.05$). The addition of fertilisers to loam gave an increased total plant weight ($P = 0.01$) which was not further increased by the addition of sodium alginate, but which was increased by the addition of carboxymethyl cellulose ($P = 0.01$) and by organic material ($P = 0.05$). These two last treatments gave increases in yield of fruit.

DISCUSSION

The growth of the tomatoes in loam without the addition of organic material or the suggested substitutes would indicate that the loam used, providing fertilisers were added, was of a quality fairly suitable for the crop; this probably accounted for the relatively small treatment differences. The addition of organic material to loam without including fertilisers, gave no significant increase in plant growth or yield. However, the addition of organic material to loam plus fertilisers considerably

improved the appearance and weight of the plants at the planting-out stage, which, under winter conditions of light, is usually eight to nine weeks after sowing. This improvement was no longer evident at the end of the experiment in flats during 1950, but with the pots, where the available soil per plant was less than in flats, the addition of organic material to loam and fertilisers did give an increase in both total plant weight and yield.

The use of sodium alginate with fertilisers gave equally good seedlings at the planting-out stage in 1950 as did the organic material plus fertilisers mixture, although this had not been the case in 1949. The 1950 results agree with the claim of Owen (1949) that for the propagating of tomato seedlings sodium alginate or some such substitute could replace organic material. The work of this Division, however, often requires that the plants be carried on to fruit in the one container, so that it was thought desirable to pursue that course in these trials. In neither season did the addition of sodium alginate to loam and fertilisers give an increase in total plant weight or yield when compared with the loam-plus-fertlisier mixture. These trials suggest that sodium alginate is of doubtful value under local conditions, particularly as there is the risk of it depressing emergence.

Carboxymethyl cellulose, although tested in only one year, 1950, appeared to be more promising in that it gave results comparable with those for organic material in the full mixtures, i.e. with fertilisers. This applies particularly to the raising of plants to the planting-out stage in flats, and to carrying the plants to maturity in pots. It would appear that the possibility of substituting carboxymethyl cellulose for the rotted organic material ordinarily used with soils for raising plants would justify further investigation. It is evident that such a substitution is dependent on the inclusion of fertilisers in the mixture, as carboxymethyl cellulose when added to loam alone tended to depress growth. However, such depression is not unexpected when it is realised that the addition of this substance, as contrasted with the addition of well rotted organic material, is analogous to the inclusion of unrotted cellulose-rich plant material to soil without the provision of a nitrogenous fertiliser.

ACKNOWLEDGMENT

The author wishes to acknowledge the assistance of H. R. Thompson of Applied Mathematics Laboratory in doing the statistical analysis.

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VIRUS INFECTION IN CERTIFIED SEED POTATOES

By C. H. Procter, Plant Diseases Division, Department of Scientific and Industrial Research, Auckland

(*Received for publication, 9 April 1951*)

Introduction

In those countries where a certification scheme based on visual inspection and rogueing has been in operation, the aphis-carried viruses, leaf roll and potato virus Y, have been largely eliminated from seed potato stocks. Such certification schemes do not, however, eliminate masked forms of potato virus X. Thus in Britain and elsewhere, it has been found that stocks of many of the major varieties are extensively infected with this virus. It has been established that such mild infections, though causing no visible leaf symptoms, may reduce yields by 10-15 per cent (Bald, 1943; Smith and Markham, 1945). As stocks of many varieties are often virtually 100 per cent infected, aggregate losses are high.

Chamberlain (1940) showed that Aucklander Short Top potatoes carried at least one virus in masked form, and that infection in this variety was high. Matthews (1940) tested ten tubers of each of 18 lines of Dakota, and found no plants free of potato virus X. Apart from these records, there is very little information regarding the incidence of masked virus infection in New Zealand potato stocks

A survey of the major potato varieties grown in New Zealand has been undertaken to determine the extent of masked virus infection.

Experimental Procedure

Material for testing was collected from crops under certification in the Canterbury area. In some cases leaf material from the field was collected and tested directly. In others, material was obtained from plants raised in the glasshouse from tubers collected from the field. Tests were made by mechanical inoculation to two indicator species: *Datura stramonium* for detection of mild strains of potato virus X; and tobacco (variety—White Burley) for detection of potato viruses X and Y. Material from each potato plant under test was used to inoculate two plants of each of the test species.

Results

Results are summarised in Table I. Varieties are listed in the order of acreage under certification, as determined from the list of Provisionally Certified Growers for 1948-49.

Results in Table I indicate that two varieties, Epicure and Jersey Bennes (International Kidney), which are field immune to the commonly occurring strains of potato virus X, were free from infection. The remaining 14 varieties showed virus infection of varying degrees.

Aucklander Short Top, Arran Banner, Dakota, Aucklander Tall Top, and Inverness Favourite showed 100 per cent infection with potato virus X.

TABLE I

MASKED VIRUS INFECTION IN CROPS OF THE MAIN POTATO VARIETIES GROWN IN NEW ZEALAND.

VARIETY	AREA GROWN (AC.)	PLANTS TESTED	PLANTS HEALTHY	PLANTS INFECTED VIRUS X	PLANTS INFECTED VIRUS Y
Aucklander Short Top	1913	15 (5)	0	15	14
Arran Chief	901½	50 (5)	38	12	0
Arran Banner	696½	48 (5)	0	48	0
Dakota	582	48 (5)	0	48	2
Aucklander Tall Top	194	26 (5)	0	26	9
Inverness Favourite	151½	54 (5)	0	54	2
Sebago	133	46 (5)	10	36	0
Epicure	99½	30 (3)	30	0	0
Dunbar Standard	76	40 (4)	13	27	0
Katahdin	50	20 (2)	12	8	0
Cliffs Kidney	43	10 (1)	3	7	0
Iron Duke (President)	40	49 (5)	20	29	1
Jersey Bennes (International Kidney)	32	10 (1)	10	0	0
Majestic	29	40 (4)	9	31	1
Glen Ilam	27	49 (5)	20	29	0
Chippewa	25	10 (1)	4	6	0

The figure in brackets indicates the number of different crops from which plants were tested.

With some of the varieties, samples from different crops showed considerable variation in the infection with virus. In Arran Chief samples from two crops were found to be free of virus, while the other crops showed varying degrees of infection. In Majestic, samples from one crop showed only 20 per cent infection, while with four other crops infection ranged from 50-90 per cent. In Iron Duke, samples from one crop were 100 per cent infected, while from four other crops infection ranged from 40-60 per cent. Incidence of virus in samples of the remaining five varieties ranged from 40-90 per cent. In addition to results shown in the table, a further 95 samples of Aucklander Short Top were tested and were all found to be infected with virus.

The fact that in some varieties all samples, and in other varieties the samples from certain crops, were free of virus infection indicates the possibility of securing, without any further selection, lines of some potato varieties comparatively free from Virus X.

Aucklander Short Top also showed virtually 100 per cent infection with virus Y, whilst Aucklander Tall Top showed approximately 30 per cent infection. The New Zealand certification scheme tolerates a small percentage of visible mosaic in certified crops. This fact probably accounts for the presence of potato virus Y in a low percentage of samples of Dakota, Inverness Favourite, Majestic, and Iron Duke (President).

It is of considerable interest that two of the major New Zealand varieties, Aucklander Short Top and Aucklander Tall Top, should carry potato virus Y in a masked form. The presence of this aphis-transmitted virus in these varieties makes them a potential source of infection to adjacent crops of other varieties.

As a result of this survey, a search is being made, in collaboration with the Crop Research Division, Department of Scientific and Industrial Research, for virus-free material of the varieties Aucklander Short Top and Dakota to act as a nucleus for building up virus free lines.

ACKNOWLEDGMENTS

Appreciation for their help is expressed to those officers of the Crop Research Division, Department of Scientific and Industrial Research, Lincoln, and Extension Division of the Department of Agriculture who collected the samples from the field for this survey.

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REVIEW

JOURNAL OF SOIL SCIENCE, VOL. 2, NO. 2.

Edited by G. V. Jacks, Oxford University Press, London, 1951, 127 pp.

This number begins with an excellent appreciation of the work and personality of the late G. W. Robinson by C. G. T. Morison.

In continuation of the policy of the three preceding numbers the eleven papers embrace a wide variety of soil investigations. Reports of field studies comprise an informative account of the profiles, chemical and clay mineral data of the chief soil groups in Syria by A. Muir, and a detailed description of warping and the resulting soils in Yorkshire, by W. R. Heathcote. Pedologists and physicists interested in sandy soils will be interested in the explanation given by M. Rim for the formation of stratified layers in soil materials on the coastal plains of Israel. Pedologists and soil chemists alike will welcome the well designed yet simple series of experiments on the mechanism of gley formation by C. Bloomfield, and his important conclusions on the role of micro-organisms and the movement of iron in gleying.

The scope of other laboratory studies are indicated in the following titles: A Cylindrical Gypsum Block for Moisture Studies in Deep Soils of Kenya by H. C. Pereira; Phosphate Fixation by Clay Minerals: Montmorillonite and Kaolinite by B. Chatterjee and S. Datta; Fixation of Phosphate during the Acid Extraction of Soils by G. W. Cooke; A Study of Various Fractions of the Manganese of Neutral and Alkaline Organic Soils by S. G. Heintze and P. J. G. Mann; On pC, pS, and pN as Indicating Functions of Electrical Soil Conductivity by C. L. Whittles and E. K. Schofield-Palmer; The Effect of Soil Calcium on the Mineral Content of Wheat by W. E. Chambers and H. W. Gardner; Characterization of Belgian Sea-polder Soils by the Clay Fraction and Cation-Exchange Capacity by L. de Leenheer and M. de Boodt.

Photographs and diagrams are clear and the whole production is of high quality.

H. S. G.

METHODS FOR DETERMINING THE VIABILITY OF VARIOUS SEEDS BY TETRAZOLIUM STAINING

II. PERENNIAL RYEGRASS

By E. O. C. Hyde, Grasslands Division, Department of Scientific and Industrial Research, Palmerston North

(*Received for publication, 20 November 1951*)

Summary

A method is described by which the viability of perennial ryegrass seed was determined within 24 hr. The seed was presoaked for 16 hr at 30°c., sterilized with calcium hypochlorite, bisected, and steeped in a 1 per cent solution of 2, 3, 5-triphenyltetrazolium bromide for 6 hr at 30° c.

Seeds were regarded as viable if no part of the embryo failed to stain other than the coleorhiza and the primary root tip.

The proportion of viable seeds in each of 48 different lots was estimated by both the staining and the germination methods. The results were in close agreement for samples ranging in viability from 0 to 97 per cent.

It is concluded that the staining method is reliable and suitable for urgent tests.

Introduction

The present paper, the second of a series[1], deals with Perennial ryegrass, *Lolium perenne* L., which was selected for study because it is the most widely sown pasture grass in New Zealand, and because the seed is most variable in quality. Newly harvested seed is frequently of low germination capacity due mainly to the blind-seed disease[2]. Because of the uncertain quality of the seed, estimates of germination capacity are often required in a shorter time than the 14-day germination test allows. While estimates based upon the proportion of disease-free seed have been used[3] they are subject to large errors, and a method that is both rapid and reliable is needed.

It has been found impracticable to employ for all species the same method of staining with tetrazolium. The pretreatment of the seed, and the techniques for applying the stain and for examining the embryos have had to be modified for different species[1, 4, 5].

The degree of staining which indicates viability is also dissimilar for different species because the extent and location of non-essential tissue in the embryo varies. Lakon[6] has shown that in grasses with numerous seminal roots the death of some of the root primordia does not disable the seedling, and he has established that seeds in which only non-essential parts fail to react to the stain should be regarded as viable. To determine the appropriate criterion of viability for any species it is therefore necessary to know the location and the importance of all primordia in the embryo.

The objects of the present work were to develop a satisfactory method for staining perennial ryegrass embryos, to ascertain what degree of staining should be regarded as the criterion of viability, and to compare the staining method of determining the viability of perennial ryegrass seed with the germination method.

EXPERIMENTAL METHODS AND RESULTS

Materials used

Forty-eight lots of perennial ryegrass seed which had been stored in paper containers under ordinary room conditions of temperature and humidity were tested. The origin and age of the seed are shown in Table I. A germination test had been carried out on each lot when received, and these tests, taken in conjunction with the observed incidence of blind-seed disease, indicated that this disease had been the main cause of loss of viability up to the commencement of the storage period. Later germination tests showed that in the older lots a marked decline in germination capacity had taken place during storage.

TABLE I. RESULTS OF TESTS FOR STAINING REACTION AND FOR GERMINATION CARRIED OUT ON TWO SEPARATE SAMPLES FROM EACH OF 48 DIFFERENT LOTS OF PERENNIAL RYEGRASS SEED

Seed Lot			Analysis by Tetrazolium Staining								Analysis by germination counts		
			Number of seeds in each embryo staining class										
No	Origin	Date of Harvest	1	2	3	4	5	6	7-12	Seeds counted as viable. Total Classes 1 + 2	Viable seed	Seeds producing abnormal growths not classed as viable	Non-germinating remainder
1	N.Z.	1942	1					398	1	1	0	2	398
2	"	1947	2	2	1	6	1	388		4	5	4	391
3	Scotland	1944	14	4	1	18	6	354	3	18	13		387
4	N.Z.	1946	15	4	2	12	9	358		19	21	2	377
5	Denmark	1947	46	8	11	18	2	313	2	54	66	8	326
6	N.Z.	1944	37	17	9	36	22	279		54	50	5	345
7	"	1949	48	21	8	15	20	288		69	67	2	331
8	"	1949	73	8	1	8	1	309		81	76	3	321
9	"	1946	82	19	7	23	16	253		101	93	5	302
10	"	1946	95	12	3	9	2	277	2	107	108	5	287
11	"	1946	100	10	4	9	18	257	2	110	103	2	295
12	"	1948	106	26	25	34	14	195		132	130	29	241
13	"	1947	145	21	8	26	2	197	1	166	173	4	223
14	"	1947	184	6	4	21		185		190	183	9	208
15	"	1947	181	16	2	7	3	191		197	174	5	221
16	Canada	1948	187	14	26	10	21	140	2	201	175	26	199
17	N.Z.	1947	184	18	7	19	5	167		202	208	7	185
18	"	1946	168	36	4	26	13	151	2	204	194	7	199
19	"	1949	203	5	1	1	1	189		208	179	2	219
20	"	1949	199	10	2		1	188		209	182	3	215
21	"	1949	197	13	7	7		174	2	210	246	3	151
22	"	1947	201	11		7	6	175		212	231	5	164
23	"	1949	235	2				163		237	243	1	156
24	"	1949	234	9		3	1	152	1	243	222	5	174
25	"	1949	232	13	5	4	6	140		245	251	2	147
26	"	1949	266	3				131		269	240	1	159
27	"	1949	276	3	5			115	1	279	293	1	106
28	"	1949	283	2		2		112	1	285	287	1	112
29	"	1949	284	4	1	6	1	103	1	288	275		125
30	"	1949	290	3	1	2		104		293	271	1	128
31	"	1948	280	15	2	9	14	79	1	295	289	5	106
32	England	1947	284	29	2	11	12	62		313	295	3	102
33	Wales	1947	308	13	1	8	8	62		321	336	4	60
34	"	1947	331	6	1		2	60		337	346	3	51
35	N.Z.	1947	333	12		6		49		345	344	3	53
36	"	1948	335	3	1	3	1	47		348	363	2	35
37	"	1948	348	3	2	1	3	41	2	351	344		56
38	Canada	1948	350	6	6	4	3	29	2	356	368		32
39	N.Z.	1949	353	5	2	6		31	3	358	348	5	47
40	"	1947	360	7		4	2	26	1	367	381	2	17
41	"	1948	361	6	6	7	3	17		367	378	4	18
42	Wales	1947	360	13	4	2	3	17	1	373	378	3	19
43	N.Z.	1949	364	11	4	2	1	18		375	376		24
44	"	1948	375	2	1	3		19		378	378		22
45	"	1948	380	1				19		381	374	1	25
46	"	1948	382	4	4	6		3	1	386	373		27
47	"	1948	383	4				13		387	390		10
48	"	1948	387	1	3			9		388	380		20

Staining procedure

To determine the most satisfactory method of staining the embryos various treatments were applied to samples of seed of known germination capacity. Staining was carried out at 20°, 25° 30° and 35°c. for different periods of time up to 24 hr. The speed of staining was greatest at the higher temperatures. At 30°c. all seeds capable of reacting were stained with sufficient intensity within 5 hr. It was found that the temperature and duration of the preparatory soaking treatment could be varied within wide limits without perceptible influence upon the staining. Satisfactory results were obtained when the seed was allowed to become fully imbibed at any temperature between 15° and 30°c. Eight hours at the higher temperature was sufficient, but it was generally more convenient to allow the seed to soak overnight.

Solutions of 2, 3, 5 - triphenyltetrazolium bromide were used at concentrations of $\frac{1}{2}$, 1, 2 and 3 per cent. Staining was more rapid at 1 per cent than at $\frac{1}{2}$ per cent, but the higher concentrations produced no further increase in speed or intensity of staining.

The stain was applied to intact seeds, to seeds in which the pericarp had been pierced, and to seeds bisected so as to divide the embryo lengthwise. Bisecting the seeds before staining was most satisfactory. In this way, uniformly rapid staining was assured and the distribution of the stained tissue within the embryo could be observed without further dissection. Manipulation of the bisected seeds was greatly facilitated if the two halves of each seed were left attached to each other at the upper end.

Some samples required to be surface sterilized to prevent bacterial reduction of the tetrazolium which otherwise confused the test.

The staining procedure which gave the most consistent results and which was later employed for the comparative tests comprised the following steps:

(1) From a sample freed from all impurities, 400 seeds were counted at random and soaked in tap water at 30°c. for 16 hr.
(2) The seeds were sterilized by steeping for 10 to 15 min in a solution of calcium hypochlorite containing approximately 1 part per 1,000 of available chlorine.
(3) After washing in sterile water, the seeds were each bisected for about 2/3 the length of the caryopsis so that a sagittal section of the embryo could be exposed. This was done with a bent scalpel under a dissecting microscope at X10 magnification.
(4) The seeds were transferred to a small glass dish and covered with a 1 per cent solution of 2, 3, 5 - triphenyltetrazolium bromide, and incubated for 5 hr at 30°c.
(5) After being washed in tap water, the seeds were examined at X20 magnification and classified according to the distribution of stained tissue in the embryo.

The staining tests were completed within 24 hr and occupied a total working time of approximately 70 min for each sample of 400 seeds.

Criterion of Viability

In order to study the germination and seedling development of perennial ryegrass, 8,000 seeds were set out on moist filter paper and examined daily. Special attention was paid to those seedlings lacking one or more of the seminal roots.

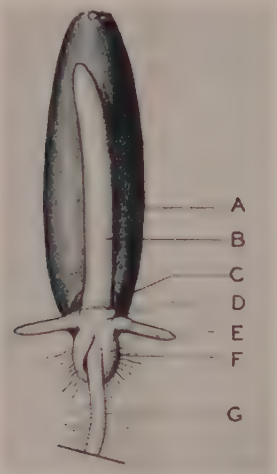

FIG. 1.—Perennial ryegrass seedling with lemma and palea removed showing normal development of the seminal roots. A—caryopsis; B—plumule; C—scutellum, covered by the pericarp; D—epiblast; E—lateral seminal root; F—coleorhiza; G primary seminal root.

Seedlings normally produced three seminal roots, a primary root, and two lateral roots as shown in Fig. 1. Seedling growth was not seriously retarded when the primary root together with its coleorhiza failed to develop, provided the lateral seminal roots appeared. Seedlings with no seminal roots grew at best so slowly that they were practically non-viable.

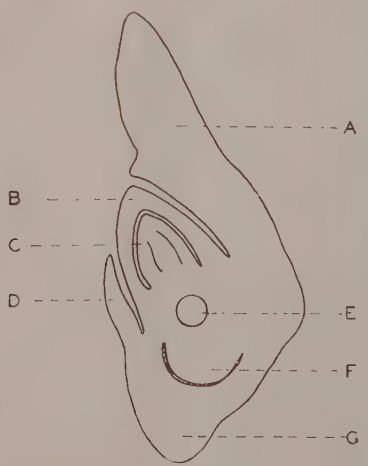

FIG. 2.—Embryo of perennial ryegrass in vertical longitudinal section; approximately 60 μ from the median plane, showing the point of origin of the lateral seminal root. A—scutellum; B—coleoptyle; C—first true leaf; D—epiblast; E—primordium of the lateral seminal root; F—main root primordium; G—coleorhiza.

To locate the primordia of different organs in the embryo, 16 seeds and 7 seedlings were sectioned. Serial sections 10 μ thick were cut by the paraffin method and stained with crystal violet.

The lateral seminal roots originate one on either side of the axis of the embryo at the level of the point of attachment of the scutellum. Generally the primordia of these lateral roots become clearly differentiated only after germination has commenced. They could be detected in only two out of the 16 seeds which were sectioned at the resting stage. One of these seeds is illustrated in Fig. 2.

It was inferred that a perennial ryegrass seed could be counted as viable even though the coleorhiza and the primordium of the main seminal root were dead and no longer capable of reducing the tetrazolium salt, provided the other parts of the embryo, including the middle region of the axis, retained their vitality and staining capacity. Of the seeds illustrated in Fig. 3, only the first two can be counted as viable according to this criterion.

Comparative tests

To compare the staining method of determining viability with the germination method, duplicate samples were taken from each of 48 different lots of seed. One sample was tested for germination while concurrently the reaction of the other sample was tested by the staining method.

Each germination test was carried out with 400 seeds counted at random from a sample freed from all impurities. Night and day temperatures in the germination incubator were 18°c. and 25°c. respectively. The testing period was 14 days. A seed was counted as viable it it produced a seedling with a plumule and one or more seminal roots. Seedlings without a plumule or without seminal roots were counted separately as abnormal growths.

The staining procedure used for the comparative tests has already been described above in detail. The seeds were classified according to the extent and distribution of the stained tissue in the embryo, twelve classes being recognised. The staining pattern typical of each class is illustrated in Fig. 3.

The germination counts and the staining reaction of the 48 different lots of perennial ryegrass seed are shown in Table I. The scatter diagram Fig. 4 shows the relationship between counts of viable seeds by the germination method, and the counts by the staining method. Each point indicates the numbers of viable seeds determined by the two different methods in separate samples from one lot of seed. The coefficient of correlation between counts was 0.9938. The equation for the regression of the germination counts on the staining counts was $y = 1.0054\ x - 3.6375$. The regression coefficient 1.0054 was compared with 1.000 by the t-test and gave $t = 0.328$ for 46 degrees of freedom, showing that the regression coefficient did not differ significantly from 1.000. The viability counts by the two methods were compared throughout the 48 seed groups by the X^2 test. The value for X^2 obtained was 43.499; as the figure required for significance is 63.935, the methods did not differ significantly by this test.

Of the 19,200 seeds examined 6.8 per cent had partially stained embryos. Of these, 97.6 per cent were in Classes 2 - 5 and only 2.4 per cent in Classes 7 - 12.

Seeds showing the symptoms of blind-seed disease perceptible at low magnification[3] almost all fell into Class 6, whereas the disease-free seeds were distributed among all classes.

FIG. 3.—Saggital sections of perennial ryegrass embryos showing typical staining patterns (stained tissue stippled). Classes 1 and 2 only were counted as viable.

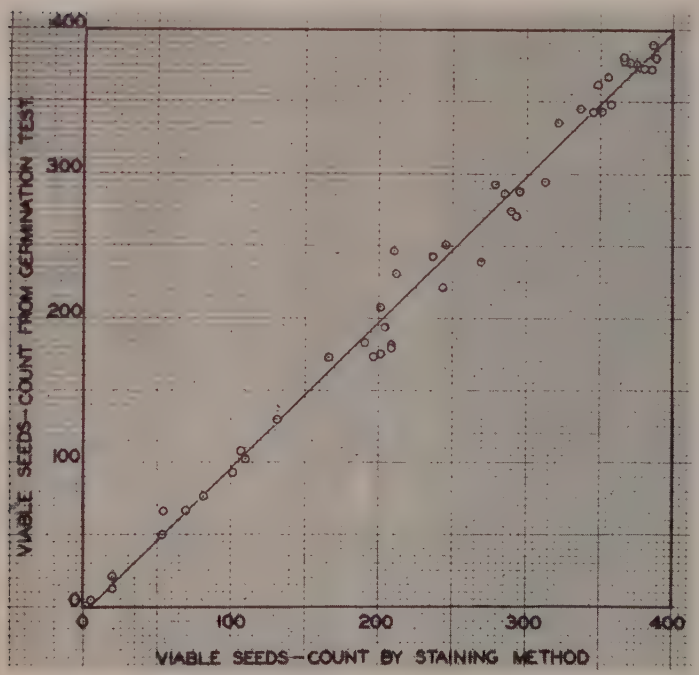

FIG. 4.—Scatter diagram showing the relation between counts of viable seeds by the staining method and by germination test. $Y = 1.0054\ X - 3.6375$.

DISCUSSION

The method of staining found most suitable for perennial ryegrass resembles that recommended by Lakon[7] for maize, except that a higher temperature, a longer period of staining, and surface sterilization of the seed were required. Also, to facilitate the handling of such small seeds it was necessary to keep the halves of bisected seeds attached to each other.

The coefficient of regression of germination counts on staining counts indicates that the criterion of viability adopted was appropriate. The criterion was unusual in that seeds were counted as viable in which there were no stained root primordia. It was sufficient that the central portion of the embryo axis from which the lateral seminal roots arise during germination should retain the capacity to react. The X^2 test indicates that the staining method gives consistently good results at all germination percentages.

It was previously observed[1] that the distribution of seed in classes, based upon embryo staining, differed according to the factor causing loss of vitality; and a further example of this was found in perennial ryegrass. Seeds attacked by the blind-seed disease nearly all fell into Class 6 while disease-free seeds which were declining in vitality due to age were distributed among all classes.

The occurrence of partially stained embryos indicates that the loss of vitality in ageing seeds takes place sooner in some parts of the embryo than in others. The staining patterns indicate which organs are most prone to lose vitality. Classes 2 - 5 inclusive form a series in which loss of staining capacity in the tissue of the embryo extends gradually upwards from the coleorhiza to the top of the scutellum. It is reasonable to infer that these classes represent progressive stages through which a seed normally passes as it loses vitality under ordinary storage conditions. This is in accord with Lakon's conclusion[6] that in wheat, oats and rye-corn the root primordia are the parts of the embryo which most readily lose their vitality.

Classes 7 - 12 do not represent stages in the normal spread of necrosis through the embryo. Seeds in these classes occurred infrequently and some factor not generally effective under the conditions of storage may have contributed to the loss of vitality.

It is concluded that the tetrazolium stain provides a reliable and rapid means of determining the viability of perennial ryegrass seed. The staining method is suitable for urgent tests, but where there is sufficient time the germination method is preferable because it is less exacting.

ACKNOWLEDGMENT

The writer is indebted to Mr. A. C. Glenday for assistance with the statistical analysis of the results.

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SEED DISINFECTION

III. EFFECT OF SEED DRESSINGS APPLIED AT DIFFERENT CONCENTRATIONS ON EMERGENCE OF VEGETABLE SEEDLINGS

By H. Jacks, Plant Diseases Division, Department of Scientific and Industrial Research, Auckland

(*Received for publication, 14 November 1951*)

Summary

Cuprocide, Spergon, Panogen, thiram, ferbam, Dow 9 B, and 36 L in various dosages were applied as seed dressings to lettuce, pea, bean, beet, turnip, tomato and celery seeds to determine effect on emergence.

Optimum dosages as measured by percentages emergence and expressed as percentages of seed weight, varied with the material and different seeds treated. These optimum dosages, omitting reference to materials which were not effective, are listed below.

(1) Lettuce: ferbam at 0.25 and all other materials at 0.5 per cent of seed weight.

(2) Pea: 36 L at 0.063, thiram at 0.125, ferbam and Dow 9 B at 0.5, and all other materials at 0.25 per cent.

(3) Bean: Spergon and Panogen at 0.25, ferbam at 0.5, and all other materials at 0.125 per cent.

(4) Beet: Panogen, Dow 9 B, and 36 L at 0.5, and thiram at 1.0 per cent.

(5) Turnip: 36 L at 0.25 per cent.

(6) Tomato: Panogen at 2.0, and all other materials except Cuprocide at 1.0 per cent.

(7) Celery: ferbam at 0.5 per cent.

Introduction

The standard recommendations of manufacturers for dosages of seed dressings are 2 per cent of seed weight for small seeds and 0.25 per cent for large seeds. It seemed, however, that such general recommendations did not allow for possible varying effects with different seeds. This work was therefore undertaken to determine the effect of applying a range of concentrations of materials to seeds of lettuce, pea, bean, beet, turnip, tomato and celery in order to discover which were the most suitable concentrations.

Experimental Methods and Results

Materials and methods of application have been described in a previous paper (Jacks, 1951). To secure adherence of the dressings at higher concentrations, a preliminary treatment with a wetting agent was given. This was prepared by dissolving 3 g. resin in 10 ml. methylated ethyl alcohol and was used at 0.25 per cent of seed weight. Tests showed that this treatment did not affect germination. Weighed amounts of seeds and seed dressings were mixed to obtain required dosages. The percentages of seed dressings which adhered were assessed by re-weighing. Further small quantities of seed dressings were added when concentrations were below those required, the process being repeated until the required dosage was secured.

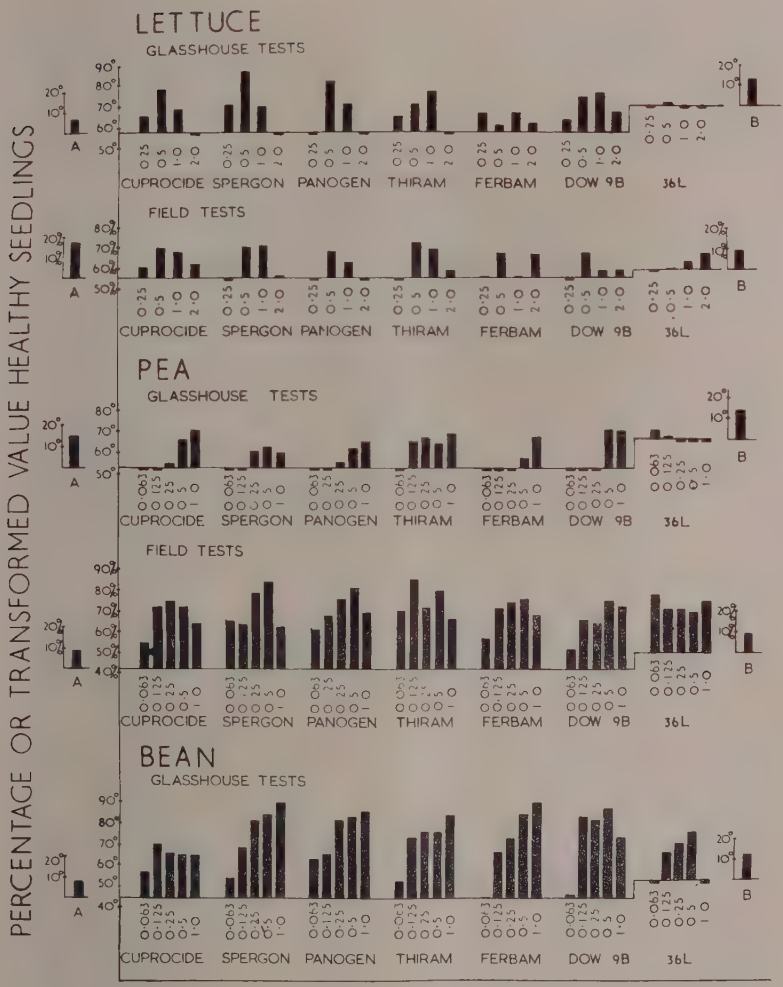

FIG. 1.—Effect of concentration of seed dressings on seedling emergence. Results of glasshouse and field tests with lettuce, pea and bean. Transformed values have been used for glasshouse tests and actual percentages for field tests. Columns shown above the line are those significantly greater than control. Those indicated by a short column below the line were either not significantly different from controls or were significantly lower than controls. Columns in margin at A show in each case differences required for significance in respective treatments, except for 36 L for which this difference is shown at B.

Glasshouse experiments were carried out at 16.9° ± 3.4° c. with unsterilized soil maintained at 45 per cent water holding capacity (w.h.c.). The effect of dosage levels on emergence of lettuce and pea was also tested in the field at temperatures of 8.5° ± 4.6° c. and soil moistures of 42.7 ± 3.3 per cent w.h.c. Methods of soil preparation, planting and recording of glasshouse and field trials have been reported previously (Jacks, 1951).

Results of both glasshouse and field trials are given in Figs. 1 and 2, where values of stands significantly higher than control levels are illustrated. Tests with 36 L were carried out later than with the other seed dressings and it will be noted that the level of the control for this material is different from that for others. To obtain data shown in Figs. 1 and 2, percentages emergence were transformed to degrees (Fisher and Yates, 1948), except in the case of field tests where percentages are given.

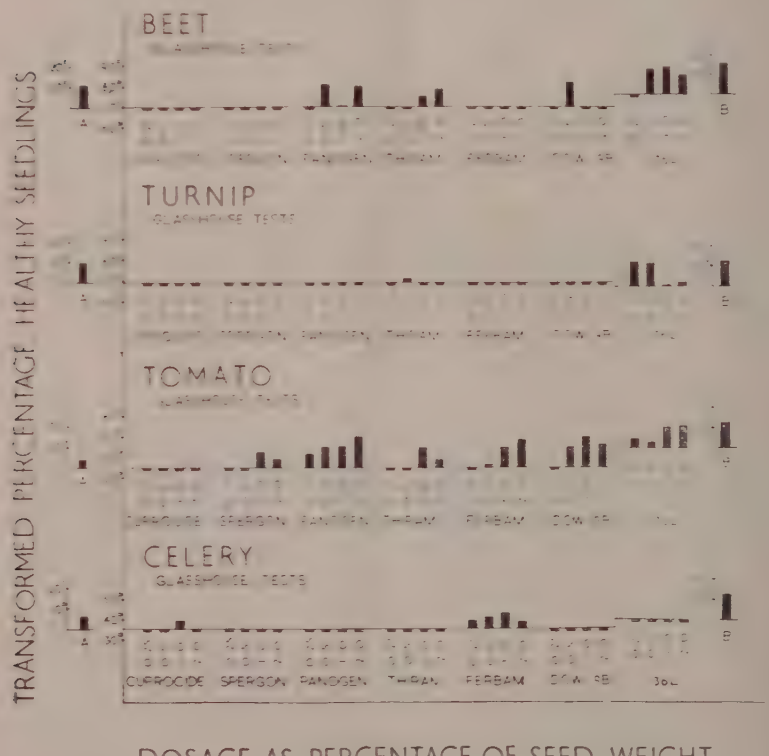

FIG. 2.—Effect of concentration of seed dressings on seedling emergence. Results of glasshouse tests with beet, turnip, tomato and celery. Transformed values have been used. Columns shown above the line are those significantly greater than control. Those indicated by a short column below the line were either not significantly different from controls or were significantly lower than controls. Columns in margin at A show in each case differences required for significance in respective treatments, except for 36 L for which this difference is shown at B.

DISCUSSION

Examination of Figs. 1 and 2 shows how differently the various seeds reacted to dressings. In general, lettuce, pea, and bean reacted favourably to application of seed dressings. With beet, turnip, tomato and celery, response was less effective. Tomato responded to all treatments except Cuprocide, whereas emergence of beet was increased only by Panogen, thiram, Dow 9 B, and 36 L, that of turnip by 36 L, and of celery by ferbam.

Some materials, viz. Cuprocide, Spergon, Panogen and thiram, at 2 per cent concentrations depressed emergence of lettuce below the level attained by the 0.5 and 1.0 per cent dosages; this was especially noticeable in glasshouse tests. Depressing effects can only be attributed to phytocidal damage. Peas, beans, turnip, tomato and celery were not as sensitive to higher dosages. Beet was sensitive to all concentrations of Spergon. Results suggest that careful dosage estimation is necessary for such seeds as are known to be sensitive to certain substances.

Optimum dosages are the lowest concentrations that significantly increased emergence of seedlings over controls, and which were not significantly less effective than other concentrations under test. For seeds responding to the various treatments optimum dosages were as follows:

(1) Lettuce: ferbam at 0.25, and all other materials at 0.5 per cent.

(2) Pea: 36 L at 0.063, thiram at 0.125, ferbam and Dow 9 B at 0.5 and other materials at 0.25 per cent.

(3) Bean: Spergon and Panogen at 0.25, ferbam at 0.5, and all other substances at 0.125 per cent.

(*Note.*—Concentrations of 1.0 per cent with peas and beans are considered excessive as this amount will not adhere satisfactorily under practical conditions. For this reason, results with 1.0 per cent have been left out of consideration in determining optimum dosage.)

(4) Beet, Panogen, Dow 9 B, and 36 L at 0.5, and thiram at 1.0 per cent.

(5) Turnip: 36 L at 0.25 per cent.

(6) Tomato: Panogen at 2.0, and all other materials except Cuprocide at 1.0 per cent.

(7) Celery: ferbam at 0.5 per cent of seed weight.

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SEED DISINFECTION

IV. EFFECT OF SEED DRESSINGS, APPLIED SEPARATELY OR AS MIXTURES, ON EMERGENCE OF CERTAIN VEGETABLE SEEDS

By H. Jacks, Plant Diseases Division, Department of Scientific and Industrial Research, Auckland

(*Received for publication, 10 October 1951*)

Summary

Application of mixed seed protectant substances to vegetable seeds sown both in the glasshouse and in the field showed that no advantage was gained over their separate use.

Introduction

In previous seed treatment experiments (Jacks, 1951), both thiram and Spergon proved effective for increasing emergence of lettuce and pea; thiram and ferbam for turnip and Panogen, and Cuprocide for beet; with all the above seeds, 36 L had also been found useful in the same tests. Since these substances differ in their bactericidal and fungicidal effects, tests were carried out to determine whether mixtures would improve emergence rates.

Materials and Methods

Materials used in these tests were as follows:—

(1) Cuprocide (94 per cent red cuprous oxide),
(2) ferbam (100 per cent ferric dimethyl dithiocarbamate),
(3) Panogen (0.8 per cent methyl mercury dicyan diamide),
(4) Spergon (98 per cent tetrachloro-para-benzoquinone),
(5) thiram (100 per cent tetramethyl thiuram disulphide),
(6) 36 L (100 per cent 1-p-sulphamyl phenyl-3:5-dimethyl-4-nitrosopyrazole).

Sources of vegetable seeds and methods of soil preparation, sowing and recording have been described (Jacks, 1951).

Seed treatment methods have also been described. Where combinations were applied, equal weights of each dust were mixed prior to application. Panogen, a liquid preparation, was applied prior to application of dusts.

Results

Figures obtained in glasshouse and field experiments are set out in Tables I and II.

It is apparent that seed treatment with mixtures of materials which individually improved emergence had, in general, no advantage over the separate components of each combination. In fact, in a large number of cases in both glasshouse and field tests, application of combinations resulted in significant depression of emergence compared with results

TABLE I. PERCENTAGE EMERGENCE OF LETTUCE AND PEA SEEDS IN THE GLASSHOUSE (Temperature, 16° to 20° C.; Soil Moisture, 45 per cent W.H.C.)

Treatment	Percentage emergence of seeds at dosages* indicated									
	Lettuce				Pea					
	0.25	0.5	1.0	2.0	0.032	0.063	0.125	0.25	0.5	1.0
Control	57.0	57.0	57.0	57.0	55.6	55.6	55.6	55.6	55.6	55.6
thiram	84.7	90.5	92.7	76.4	55.1	59.0	72.5	71.0	70.2	77.5
Spergon	81.0	87.7	85.4	70.2	41.5	46.8	57.9	67.8	67.8	66.9
thiram + Spergon	55.7	82.2	91.6	85.8	28.7	40.9	61.6	64.9	61.0	85.9
36L	81.1	95.5	87.5	86.1	78.2	83.4	80.8	79.3	78.3	79.9
thiram + 36L	61.7	85.5	79.3	40.1	47.1	43.8	50.7	70.0	75.7	69.5
Spergon + 36L	75.9	89.9	84.9	74.0	31.7	42.1	62.7	73.8	54.2	76.0
thiram + Spergon + 36L	79.8	91.7	75.4	69.6	47.1	56.6	57.9	42.7	55.0	70.2
Difference required for significance at 5% level	6.1	6.1	6.1	6.1	8.2	8.2	8.2	8.2	8.2	8.2

* Dosages expressed as percentage of seed weight

TABLE II. PERCENTAGE EMERGENCE OF LETTUCE, PEA, TURNIP AND BEET SEEDS IN THE FIELD (Temperature, 8° to 10° C; Soil Moisture, 40 to 42 per cent W.H.C.)

Treatment	Percentage emergence of seeds at dosage* indicated			
	Lettuce	Pea	Turnip	Beet
	0.5	0.25	0.5	1.0
Control	52.5	63.8	46.8	186.3
thiram	72.1	86.3	81.8	-
Spergon	69.0	82.2	-	-
thiram + Spergon	62.3	80.3	-	-
36L	62.4	78.5	68.0	318.0
thiram + 36L	61.3	79.9	61.0	-
Spergon + 36L	61.5	76.9	-	-
thiram + Spergon + 36L	57.6	74.5	-	-
ferbam	-	-	58.0	-
thiram + ferbam	-	-	59.8	-
ferbam + 36L	-	-	55.0	-
thiram + ferbam + 36L	-	-	65.5	-
Panogen	-	-	-	383.3
Cuprocide	-	-	-	267.0
Panogen + Cuprocide	-	-	-	278.0
Panogen + 36L	-	-	-	297.0
Cuprocide + 36L	-	-	-	300.8
Panogen + Cuprocide + 36L	-	-	-	268.5
Difference required for significance at 5% level	11.6	9.9	8.7	58.7

* Dosage expressed as percentage of seed weight

obtained from separate treatments. In only two instances was emergence significantly improved by a combination. In the glasshouse experiments with both lettuce and pea, thiram + Spergon, at the highest rate of application, proved superior to either substance applied separately. In a comparable experiment in the field, no significant differences appeared.

In general it may be concluded that mixing of any of the materials tested was not advantageous but was frequently detrimental compared with the effect of separate components.

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BOOK REVIEW

THE ASSOCIATION OF ANTS WITH APHIDS AND COCCIDS

By C. E. J. Nixon, Commonwealth Institute of Entomology, London, 1951. 35 pp. 5/-

This comprehensive and welcome account of the relationship of ants with aphids and coccids is an objective appraisal of the extensive literature on this subject.

The work is divided into an introduction followed by six sections dealing with different aspects of the association, and ends with a list of 117 literature references and an index to the insect names used in the text.

In Section II, dealing with the nature of the association, the author quotes Wheeler's ideas concerning ways in which the latter supposes aphids are modified in structure to fit them more for their relationship with ants. It must be said that these ideas leave one with the feeling that they are highly conjectural. For example, Wheeler suggested that the absence or reduction of the cornicles is unmistakeable evidence that aphids have been adapted to their life with these insects. It is well known that underground species in particular show association with ants and these do possess reduced cornicles or in some cases none at all; it could, however, quite well be argued that this modification is also more advantageous to them in their movements in soil, without any reference to ant association. Modifications in behaviour because of the association seem to be on more solid ground, but the author rightly considers them critically in the light of evidence available.

The benefit of the association to the ants is unmistakeable in that they are provided with a rich and satisfactory food, but the evidence as to just what protection the aphids and coccids derive from the association is by no means consistent. From observations in the field, it does seem that ants, if numerous enough, do at least disturb the natural enemies of coccids. A case not quoted in the publication was seen in a South African citrus grove where the population of the scale insect *Coccus hesperidum* L. was apparently greatly affected by the presence of the ant *Anopolepis custodiens*. These latter were so numerous that natural enemies of the scale were continually disturbed by the passage of the ants. Where these were kept off trees by banding, the scale was of no importance, while on unbanded trees whole branches were dying because of scale infestation. There is the further possibility that where ants have access to a tree they may conceivably by transportation of coccids be able to found new colonies and thus help the scale population to prosper.

The author concludes that his survey of the literature has brought out the need for more critical work on these associations and that many of the old ideas on the so-called symbiosis of ants and aphids or coccids appear to be in need of drastic revision. While there is evidence that the mutual benefit in some combinations of ant and coccid or aphid species may be undeniable, the relationship in other cases is by no means clear.

This publication is a capable sifting of the evidence available and is obviously the result of much careful work and thought. The author is to be congratulated on bringing forward an up-to-date summary of the data. The work should be studied by all interested in this subject, and it will undoubtedly result in a stimulation of the further research that is so obviously required. W. C.

DDT AND ARSENIC RESIDUES ON FRUIT

By P. J. Clark and E. L. Richards, Dominion Laboratory, Department of Scientific and Industrial Research, Wellington,
and
G. G. Taylor and H. Jacks, Plant Diseases Division, Department of Scientific and Industrial Research, Auckland.

(*Received for publication, 11 December 1951*)

Summary

Tomatoes, beans and apples, sprayed with formulations containing 0.1 per cent and 0.05 per cent wettable DDT, 0.1 per cent DDT emulsion and 0.3 per cent and 0.15 per cent lead arsenate have been examined to determine the amount of spray residues when harvested at varying periods after the final spray treatment. In no case was the DDT residue above 7 parts per million (p.p.m.), but arsenic trioxide figures on tomatoes and beans were in most cases above the limit of 1.5 p.p.m. fixed under the Food and Drug Regulations, 1946. Whilst there was a significant decrease in the amount of the DDT residue on tomatoes with increase in time since the final spray, such was not the case with apples up to 28 days after spraying.

Introduction

The use of DDT to replace arsenical sprays in the fruit spray programme for the control of codling moth and other chewing insects introduced the problem of controlling the amount of spray residue on the fruit at harvest time, and the results reported in this paper show the amounts present on tomatoes, beans and apples when different sprays were applied under New Zealand conditions at Auckland. Comparable dosages of DDT and arsenate were used on the same day for spraying the tomatoes and the beans, and residue determinations were made on fruit harvested at the same time.

Experimental Procedure and Results

The experiments with tomatoes commenced in 1947. Four plots of tomato plants were treated as follows:—

A. One wettable DDT spray (75 per cent *p,p'*-isomer) at the rate of $\frac{1}{2}$ lb/100 gal.

B. One wettable DDT spray at the rate of 1 lb/100 gal.

C. One lead arsenate spray 3 lb/100 gal.

D. Control untreated.

From these four plots tomatoes were picked at weekly intervals, the first picking being one week after the spray was applied; four replicates from each were submitted for analysis. For DDT determinations, the tomatoes were cut in half, the centres rejected, and the outer portions extracted in the cold with benzene. The benzene extracts were concentrated, and the *p,p'*-isomer determined by the method of Schechter (1945) and Wichman (1946), using a Spekker absorptiometer and two Ilford filters, No. 607 and No. 603. The arsenic residues were determined by the Marsh method after digestion with nitric and sulphuric acids. Results were calculated as parts per million on the whole fruit.

TABLE I. DDT AND As_2O_3 RESIDUES ON TOMATOES 1947

Period since spray (days)	DDT residue p,p^1-isomer from spray containing:		As_2O_3 residue from spray containing 0.3% lead arsenate C (p.p.m.)
	0.05% wettable DDT A (p.p.m.)	0.1% wettable DDT B (p.p.m.)	
7	0.5	0.5	1.2
14	0.6	0.5	1.0
21	0.6	0.6	0.9
28	0.6	0.5	0.4

The residue figures represent the average of analyses in duplicate of four replicates. The control samples were found to give negligible values and were then used for the preparation of standards for both DDT and arsenic trioxide.

To check the results in Table I, further tomato plots were laid out in 1948 and given a similar single spray treatment. A Beckman spectrophotometer was available in the DDT determinations for measuring the colour density at 6000A, 5100A and 4500A. The amount of p,p^1-isomer was calculated from the observed readings, using constants for each wavelength derived from standard amounts of p,p^1-isomer, o,p-isomer and the yellow colouring matter from the tomatoes. Arsenic trioxide figures were determined as before.

TABLE II. DDT AND As_2O_3 RESIDUES ON TOMATOES 1948

Period since spray (days)	DDT residue p,p^1-isomer from spray containing:		As_2O_3 residue from 0.3% lead arsenate spray (p.p.m.)
	0.1% wettable DDT (p.p.m.)	0.1% emulsion DDT (p.p.m.)	
1	2.0	3.2	2.2
2	1.8	3.7	2.5
4	2.0	3.6	2.8
7	1.5	3.6	2.4
14	1.0	3.6	1.7
21	0.6	2.1	1.4

The figures in Table II represent the average of analyses carried out on each of four replicate samples, approximately half being done in duplicate.

DDT and Arsenate on Beans

In 1950, bean plants were treated with DDT spray and lead arsenate spray, by two applications 12 days apart. DDT was determined by the method used for the tomatoes in 1948.

TABLE III. DDT AND As_2O_3 RESIDUES ON BEANS

Period since last spray (days)	DDT in spray (%)	DDT residue p,p^1-isomer (p.p.m.)	Lead arsenate in spray (%)	As_2O_3 residue (p.p.m.)
7	0.1	3.7	0.3	2.3
16	0.1	0.8	0.3	0.9
7	0.05	2.3	0.15	1.6
16	0.05	0.5	0.15	0.6

The results in Table III represent an average of determinations carried out on each of three replicate samples.

DDT on Apples

In the 1947-48 season apples were sprayed throughout the season at Havelock North and at Nelson, with wettable DDT powder applied at a concentration of 0.05 per cent p,p^1-isomer. The fruit was harvested at intervals after the last spraying, peeled, and the peelings were analysed by the method used for tomatoes in 1947, except that the benzene extracts were defatted before colour determinations were made. (Schechter, 1947.)

TABLE IV. DDT RESIDUES ON APPLES SPRAYED WITH 0.05% PARA PARA ISOMER

Variety	Period since last spray (days)	DDT residue Havelock Nth. (p.p.m.)	Nelson (p.p.m.)
Sturmer	14	5.7	1.4
„	21	6.7	1.3
„	28	4.7	1.3
Jonathan	21	3.3	—
Granny Smith	28	4.1	—
Dunns	21	—	1.3

The figures in Table IV represent an average of determinations carried out on each of four, or in some cases five, replicate samples.

All the analytical figures were subjected to statistical analysis and from the data regression lines were fitted to the figures for each experiment. The tests were designed to ascertain whether or not there was a significant decline in the amount of residue as the period after treatment increased, but only in the case of tomatoes and Sturmer apples were there sufficient data to enable conclusions to be drawn. For tomatoes, a significant decline was shown only by the lead arsenate treatment in 1947, whereas in 1948 it was apparent in all treatments. The rates of decline in the three treatments in 1948 were not significantly different. An analysis of variance was also carried out between the 0.1 per cent wettable DDT and the 0.1 per cent DDT emulsion treatments in 1948. This confirmed the result of the test of significance made between the two regression lines, and also showed that the difference between the two treatments was very marked. This would suggest that the use of wettable DDT is the better treatment in that the residues are much less than in the emulsion treatment.

For the apples, the statistical analysis showed that there was no significant decline in the amount of DDT residue over a period of 14 to 28 days after the last application.

The limits on fruit and vegetables under the Food and Drug Regulations 1946, are 7 p.p.m. for DDT and 1.5 p.p.m. for As_2O_3. Spraying with DDT preparations at a concentration of 0.1 per cent or 0.05 per cent p,p^1-isomer, with a period of two weeks between the last spraying and harvest, should result in fruit being marketed with residues meeting the requirements of the Food and Drug Regulations. Lead arsenate sprays on tomatoes and beans are not advisable, as the period between spraying and harvesting is frequently too short to allow the residue to weather to a figure below the required maximum.

Acknowledgment

The authors wish to express their thanks to the Applied Mathematics Laboratory of the Department of Science and Industrial Research, for the statistical analysis of the analytical data.

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BOOK REVIEW

GALL MIDGES OF ECONOMIC IMPORTANCE. VOL. V. TREES

By H. F. Barnes. Crosby Lockwood & Sons Ltd., London, 1951. 270 pp., plates 8.

This volume is part of a series on one of the most important groups of insects of economic importance. Many gall midges are destructive, e.g., the well known Hessian-fly of wheat, the pearleaf curling midge, the olearia midge, and the cocksfoot midge, to mention a few of local interest; others are beneficial, feeding on mites, scale insects, etc.; while quite a number live on fungi. Though a great amount of information has been collected from studies of many species, the group is by no means well known, and this work by Dr. Barnes brings together all the information scattered through the literature. It is not merely a compilation, however, because Dr. Barnes has carried out extensive original researches himself and has become a world authority on the subject.

The volumes in this series are Gall Midges of: (1) Root and Vegetable Crops, (2) Fodder Crops, (3) Fruit, (4) Ornamental Plants and Shrubs, (5) Trees, (6) Miscellaneous Crops, (7) Cereal Crops, while (8) will be Miscellaneous (Zoophagous, fungivorous, and those that attack weeds). It is obvious that this is a monumental work of great value to economic entomologists, horticulturists, agriculturists and foresters, since it covers the world and contains all available data on the subject.

The volume on Trees is of immediate interest to New Zealand forestry since it deals not only with what is known of the gall midges on our native trees, but also with the midges attacking exotics. Also, although both exotic and native trees in New Zealand are at the moment, remarkably free of insect pests of the midge type, it is possible that the problem will arise through destructive species reaching the country as time goes on. Such midges not only destroy developing seeds and cause injury to seedlings but attack the growing trees and cause timber defects.

There are two sections to the book: one on gall midges attacking coniferous trees such as Larch and species of *Pinus* including *radiata*; and the other on midges attacking broad leaved trees, including such trees as Acacia, Beech, Birch, Elm, Eucalyptus, Oak, Poplar, Southern Beech, Walnut and Willow for example. There is a host list to each section, a bibliography of 445 citations, an index of generic, specific and popular names of the midges, a plant index and a comprehensive general index.

D. M.

PREPARATION OF RADIOACTIVE PHOSPHATE FERTILIZER FOR FIELD EXPERIMENTS

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(*Received for publication, 15 January 1952*)

Summary

The paper describes the technique adopted for the production of a 20-lb sample of superphosphate, and reverted superphosphate, and details the precautions taken against health hazards to the operators.

Introduction

Radioactive fertilizers are being increasingly used in agricultural studies. Field experiments require comparatively large quantities of fertilizer and the preparation of this material necessitates the development of special equipment which will permit rapid manufacture and which will not involve health hazards to the operators.

The project described in this paper was undertaken at the request of the Rukuhia Soil Research Station, Hamilton, which required for field experiments 20 lb. of superphosphate, half of which was reverted to dicalcium phosphate.

Owing to the limited facilities at the Dominion Laboratory for the handling of radioactive materials, much of the work had to be carried out under conditions which were far from ideal, and it was necessary to improvise special handling equipment.

The basic materials used were: Nauru phosphate rock containing 38.1 per cent P_2O_5, and 52.3 per cent CaO; high grade hydrated lime containing 68.9 per cent CaO; and 65 millicuries of P^{32} contained in 27 ml of 0.019 N H_3PO_4.

Within one week of the dispatch of the radioactive isotope from Oak Ridge, the authors were able with the equipment described to have the radioactive superphosphate available to Rukuhia for testing.

Experimental Procedure

(1) *Preparation of Superphosphate*

To the phosphate rock sufficient sulphuric acid was added to convert the tricalcium phosphate to superphosphate and the excess CaO to calcium sulphate. For the rock phosphate used, 100 lb rock required 65.2 lb H_2SO_4. Sulphuric acid of specific gravity 1.605 was used for the radioactive preparation.

The finely powdered rock, 60 per cent passing through a 100 mesh B.S. sieve, was run into the calculated amount of cold H_2SO_4. The mixture was stirred for 2 min and was then dried for 24 hr at 70°c. Samples were analysed for moisture, and for total, citric-acid-soluble, and water-soluble phosphate as directed in the Regulation under the Fertilizer Act 1927.[1] The phosphate was precipitated and weighed as phosphomolybdate according to the Lorenz gravimetric method.

TABLE I. ANALYSES OF SUPERPHOSPHATE SAMPLES

Number	Moisture	P_2O_5 content		
		Total (%)	Water-Soluble (%)	Citric-Acid-Soluble (%)
Batch B	8.6	21.0	19.8	20.0
Batch F	8.9	—	19.8	19.8
Radioactive Batch	11.2	20.7	19.7	20.3

(2) *Preparation of Dicalcium Phosphate*

Little information is available in the literature on the process for the reversion of superphosphate. W. L. Hills[2] explains the method used for the preparation of radioactive fertilizers and his ideas were used as a guide although the procedure was modified in certain respects. Hydrated lime was used in place of calcium carbonate for the reversion. Preliminary trials using carbonate resulted in a considerable amount of effervescence, and there was always the possibility that the radioactive mixture would spill over the reaction vessel. When hydrated lime was used, the effervescence was controllable and the preparation could be carried out in the same pots as were used for the superphosphate reaction.

It was decided to revert freshly prepared radioactive superphosphate rather than follow Hills method where the radioactive material is added to water, into which inactive superphosphate and lime are mixed. In the procedure adopted a convenient amount of radioactive superphosphate, viz. 3 lb, was transferred to the reaction pot, 2½-3 lb of water was heated to 60°C. and sufficient added to make a slurry of the superphosphate. The mixture was stirred for 5 min and the hydrated lime (15 oz), mixed with the remaining hot water, slowly poured into the reaction vessel. After the addition of about one-third of the lime, the evolution of gas caused the mixture to rise alarmingly. At this stage, as explained below, ½ oz ethylene glycol was added. The mass subsided after a further 5-10 min rapid stirring and the rest of the lime could be safely added. The total time required for the addition of the lime was at least 30 min. The mass was stirred for a further 30 min, then transferred to the drying cabinet, and dried for 24 hr at 70°C.

Preliminary preparations indicated that it was not necessary to heat the reaction vessel in a hot water-bath during the reversion. However, with the apparatus to be described, the presence of the water-bath presented no difficulty, and was retained for the reversion of the radioactive superphosphate.

Ethylene glycol was added primarily as an antidust agent in the radioactive preparations discussed by Hills.[2] In the preliminary batches, 1 oz of glycol was added per pot to the slurry during the mixing, but difficulty was experienced in reducing the moisture content below 20 per cent in 24 hr drying at 70°C. As the presence of the glycol appeared to reduce the danger from effervescence during the reaction, ½ oz of glycol was retained in each mix. The moisture content of the reverted superphosphate after 24 hr drying was 17.8 per cent, but this could be reduced if necessary by a further 24-hr drying period to 10 per cent. The reverted superphosphate when cut from the pot formed very fine powder, the higher moisture content reducing the dust hazard.

Table II gives details of several mixes with the chemical analysis of the products.

TABLE II. ANALYSIS OF VARIOUS FERTILIZER MIXTURES USED

Batch	Mixture			Drying time at 70°C. (hr)	Moisture content (%)	P_2O_5 content		
	Super (lb)	Lime (oz)	Water† (lb)			Total	Water-soluble	Citric-Acid-Soluble
H	2½	12½	2½	24	8.5	16.3	Nil	15.3
I	2½	10	3	„	8.0	17.4	0.2	16.7
J	2½	10	2½	„	12.5	17.0	0.2	15.4
L	2½	12½	2½	„	18.5			
M	2½	12½	2½	26	19.2			
				50	9.0			
				72	3.0			
N*	3	15	2½	24	17.8	15.3	Nil	14.5

* Radioactive sample.

† The water was heated to 60°C.

For batch H the hot water jacket was not used.
Batches H, I and J were stirred for 2 hr, batches L, M and N for 1 hr.
1 oz of ethylene glycol was added to batches L and M, ½ oz to batch N.

FIG. 1.

Description of Equipment used

Fig. 1 illustrates the set-up used for opening the radioactive sample. The heavy tongs on the left were used to loosen the bakelite cap, the small tongs to remove the cap and to lift the bottle out of the concrete shield into the lead shield. The shielded clamp firmly gripped the bottle so that the contents could be poured into the sulphuric acid in the flask illustrated in Fig. 2. The wash bottle while still inverted over the flask was used to rinse the bottle with some of the acid required for the superphosphate preparation.

FIG. 2.

Fig. 2 shows the procedure adopted for weighing out the required amount of sulphuric acid. Sufficient acid for the conversion of 12 lb of phosphate rock into superphosphate was poured into the glass flask; a little acid was kept back for the washings mentioned above. One of the reaction pots was counterpoised under the flask. After adding the radioactive phosphoric acid and the sulphuric acid washings, the sample was stirred for 30 min with the electric stirrer. The required amount of sulphuric acid was run into the pot (for 3 lb rock phosphate 2 lb, 13 oz of H_2SO_4 S.G. 1.605). The lid shown on the mason jar was used for pouring radioactive superphosphate into the pots for the reversion procedure.

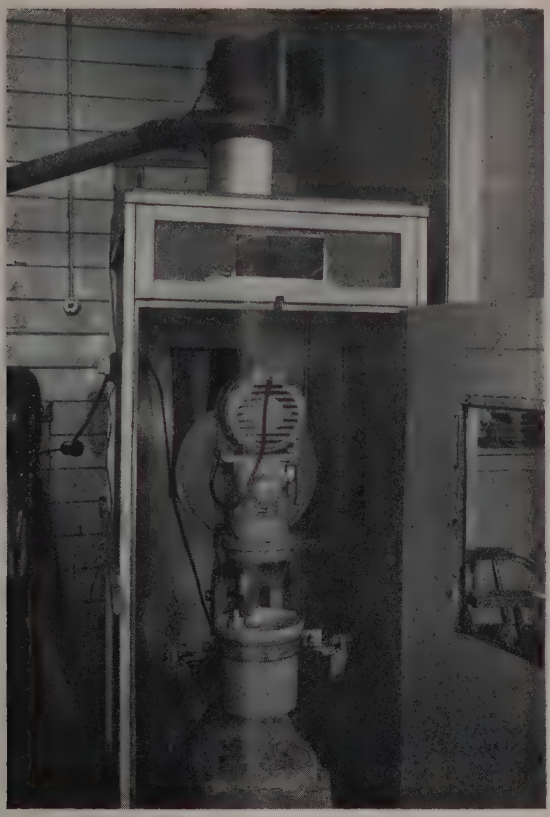

FIG. 3.

Fig. 3. The pot with the radioactive solution was removed from the scales, fitted into the collar shown in this figure and securely clamped to the cake mixer. The stainless steel stirrer was made from a retort-stand rod. The pot could be raised or lowered by the handle shown on the right and the stirrer was provided with a 3-gear mechanism that gave ideal mixing of the fertilizer materials.

The mixer was housed temporarily in a fume cabinet built of hard board and provided with the windows, doors and fittings shown. A Buffalo Forge blower removed all acid fumes, and radioactive dust particles were retained in the steel wool filter seated on top of the cabinet. The rear door on the cabinet facilitated the introduction and manipulation of equipment. The rock phosphate was poured down a small chute into the acid solution and the mixture stirred for 2 min. Acid fumes were drawn off through a short length of pipe resting against the neck of the pot and connected through the filter to the exhaust. At the end of the 2 min stirring period, the pot was lowered, the stirrer scraped as clean as possible from radioactive material, and the pot transferred to the dryer.

FIG. 4.

Fig. 4. An old tobacco dryer had to be modified for the project. The cabinet was well insulated and provided with the window as shown. A 1500-watt heater was made from four-bar elements, with two bars running continuously and the other two bars connected to a Sunvic Thermostatic Control Unit. A Centrifugal Forge blower, with a throttling device on the intake, forced air across the heating elements, and then down onto the surface of the material in the pots. The air was forced through an outlet at floor level on the rear wall of the cabinet. A throttle on the outlet could be adjusted so that the temperature of the dryer was maintained at a steady 70° ± 5°C.

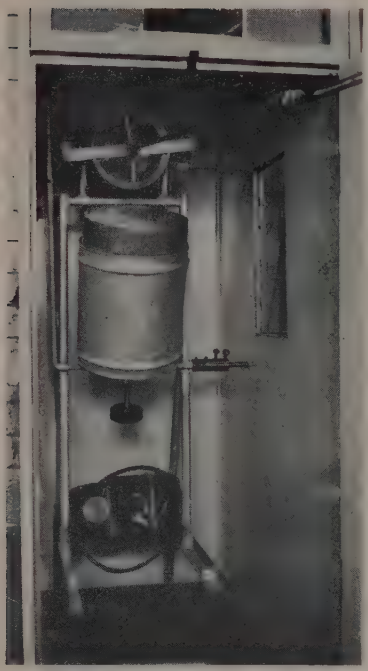

FIG. 5.

FIG. 6.

The superphosphate and the reverted superphosphate could be dried very effectively in this oven, the mass forming a relatively hard cake that could be easily cut from the pot as shown in Fig. 5.

Fig. 5 shows the fume-cabinet set-up for the cutting, sieving, mixing and bottling operations. The cutting mechanism is similar to that described by Hills[2]. The fertilizer when cut from the pot falls onto a circular 20 mesh screen fitted to a 4-gal oil drum. In the absence of suitable stainless steel equipment a 4-gal drum was fitted with side fins and adapted to operate as a concrete mixer by fitting it through a pulley mechanism to a $\frac{1}{8}$ hp worm reduction drive motor capable of revolving the drum at 18 rpm when holding 10 lb of fertilizer. When the cutter was used as shown, the fertilizer could be removed from the pot.

In Fig. 6 are shown the tools for removing the fertilizer from the drum. The tool on the left was used to break up the larger particles, and by gentle rubbing to work the fertilizer through the sieve. The tool on the right was used to chip off the small amount of fertilizer remaining on the side and bottom of the drum.

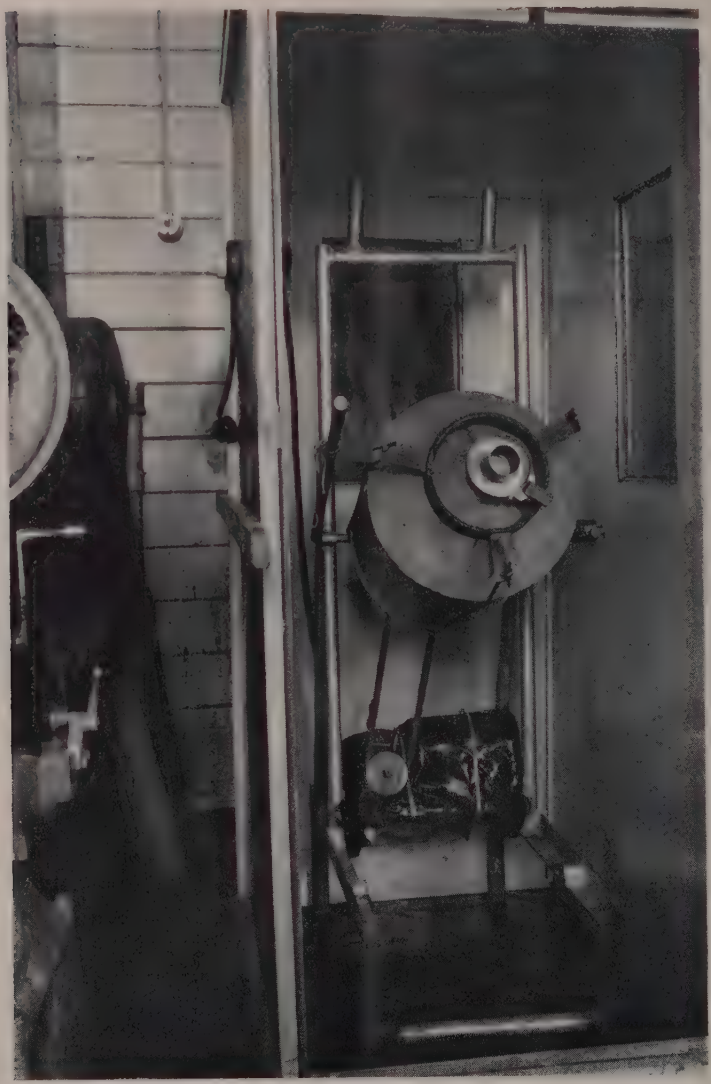

FIG. 7.

Fig. 7 illustrates the mixing operation for a 10-15 lb batch of fertilizer. The lid was clamped over the drum as shown, and the sample allowed to rotate for 30 min. The fertilizer was next bottled by screwing a mason jar to the cap shown in the figure.

FIG 8.

Fig. 8. By lowering the drum as in Fig. 8 and opening the shutter any convenient amount of fertilizer could be safely bottled. On closing the shutter and almost inverting the drum any radioactive material clinging to the cap was shaken into the jar. The jar then was removed and a further sample bottled.

FIG. 9

Fig. 9. The whole process after drying could be performed in the fume-cabinet with a minimum of dust hazard. With fertilizers of moisture content as shown in the analyses there was no tendency for it to clog up or stick in any part of the apparatus. This figure shows the method of operation outside the cabinet. The operator on the left is cutting the sample out of the pot, the one on the right is sieving the sample.

FIG. 10.

Decontamination

To facilitate decontamination all operations were carried out over black plinth paper. The radioactive particles could be easily detected and transferred to a waste container. For all operations with radioactive materials including analytical procedures, the policy adopted at the Dominion Laboratory is to keep the radioactive material completely confined at all times. This is advocated by Dr. Nelson B. Garden, of the University of California, Berkeley[3]. The analytical work on the radioactive fertilizers was performed in the gloved-box (Fig. 10) built in the Engineering Workshop. As further experience is gained these boxes will be improved in shape and service fittings so that the numerous analytical procedures that the chemist normally performs on the analytical bench or in the fume-cupboard can be carried out on radioactive materials in certain well-defined enclosures as recommended by Garden.

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NOTE ON OCCURRENCE OF A TOBACCO-NECROSIS VIRUS IN ROOTS OF LETTUCE SHOWING BIG-VEIN

By P. R. Fry, Plant Diseases Division, Department of Scientific and Industrial Research, Auckland

(*Received for publication, 5 February 1952*)

When working with the virus of lettuce-mosaic in New Zealand, the writer considered that a vein clearing symptom illustrated in his account of this disease (Fry, 1950) was a field symptom of lettuce mosaic. Following a suggestion by Dr. R. C. Thompson of the U.S. Department of Agriculture, Beltsville, that this symptom was typical of lettuce big-vein, investigations were undertaken to ascertain whether big-vein occurred in New Zealand. In the field it was found possible to differentiate the fine vein clearing of lettuce-mosaic which is usually followed by mosaic mottling, from the more pronounced clearing due to the big-vein disease (Fig. 1). Local growers state that this latter symptom is restricted to winter lettuce. A survey of nine winter crops of one to two acres in the Auckland district showed that big-vein occurred in from ten to fifty per cent of plants in eight of these, while one crop of one acre was free of symptoms.

Fig. 1.—Leaf of Imperial 847 Lettuce showing symptoms of big-vein. Healthy leaf on right. Nat. size. *Photo: S. A. Rumsey.*

The virus causing big-vein is soil transmitted (Thompson *et al.*, 1944), occurs only in roots of infected plants, can be transferred by root inoculation and has a fairly high thermal inactivation point of 65°c. for thirty minutes (Allen, 1948). Since these properties are similar to those of the tobacco-necrosis viruses (Price, 1938) trials were carried out to ascertain whether tobacco-necrosis could be recovered from roots of lettuce plants showing big-vein symptoms. Sap from roots of lettuce plants was tested by inoculation to leaves of French bean variety Sydney Wonder, three plants being inoculated from each lettuce

Results, given in Table I, show that inoculation with sap from roots of lettuce plants showing big-vein and also from symptomless plants in affected crops produced local lesions on beans. Inoculations with root sap of plants from an unaffected crop caused no lesions.

Table I.—Occurrence of a Tobacco-Necrosis Virus in Roots of Lettuce as Shown by Production of Local Lesions on Bean Leaves

Source of Inoculum Roots of:	Number of lettuce plants tested	Number of plants infected
Big-Vein lettuce	40	27
Symptomless lettuce from big-vein crops	36	15
Lettuce from a healthy crop	10	0

Inoculations with sap from infected beans produced necrotic local lesions without systemic spread on leaves of White Burley tobacco, *Nicotiana glutinosa*, cucumber and French bean varieties Sydney Wonder, Canadian Wonder and Pinto. No symptoms occurred on leaves of garden pea, broadbean, turnip, lettuce or *Lactuca saricola*. Complete thermal inactivation (ten minute treatment) of infective bean sap occurred between 94°c. and 96°c. From these characteristics it is concluded that the virus recovered from roots of lettuce plants belongs to the tobacco-necrosis group.

Attempts to produce big-vein symptoms in lettuce by inoculation of roots with infected bean sap, and by growing plants in infected soil have so far given inconclusive results. Since big-vein is a low temperature disease (Thompson and Doolittle, 1942) and the experiments were carried out in the spring when temperatures were rising rapidly, it is probable that conditions were unsuitable for expression of symptoms.

In most species naturally infected with tobacco-necrosis viruses the virus is confined to the roots. The virus causing big-vein of lettuce is also soil carried and infects only roots. In the trials reported above tobacco-necrosis virus has been recovered from roots of lettuce in all crops affected with big-vein. It is therefore considered possible that symptoms of big-vein disease of lettuce may be associated with infection of roots by a tobacco-necrosis virus.

Acknowledgment

The author wishes to acknowledge assistance given in field surveys by Mr. S. O. Gillard, Horticulture Division, Department of Agriculture.

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NOTE ON D.D.T. RESIDUES ON CABBAGES

By E. J. CLARK and I. L. RICHARDS, Dominion Laboratory, Wellington, and G. G. TAYLOR and H. JACKS, Plant Diseases Division, Auckland

(*Received for publication, 11 December 1951*)

Following experiments reported by Clark (1947) which showed the amount [illegible] first time after treatment to control white [illegible] L.) and [illegible] moth of cabbage (*Barathra brassicae ligensis Curt*), a further series of tests was commenced at Auckland. Cabbage plants were treated with DDT dusts containing 1 per cent and 2 per cent of *p,p'*-isomer DDT and with sprays made up with wettable DDT at concentrations of 0.05 and 0.1 per cent *p,p'*-isomer. There were 10 applications of each treatment between 17 February, 1947, and 16 April, 1947. Fourteen days and twenty-one days after the final treatment, cabbages were harvested and prepared for analysis. The coarse cover leaves were discarded and the remaining leaves were stripped from the heart until there could be no possibility of further penetration by DDT. After reduction in size by chopping, these leaves were extracted three times with benzene and the DDT then determined by the method of Schechter (1945), the density of the colour being measured in a Spekker absorptiometer with an Ilford filter No. 607. Fifteen cabbages in each treatment were analysed.

In calculating the values in Table I it has been assumed that the distribution of concentration of DDT, for each application, is normal with a mean, μ, and a variance σ^2. Since, irrespective of the care with which a treatment is carried out, there is always a finite chance that the concentration on some cabbage will exceed any given limit, it has been arbitrarily decided to derive the confidence limit of a point C where $C = \mu + 3.1\sigma$. If the normal assumption is true, on the average 0.1 per cent of the cabbages treated will have a concentration exceeding C. By means of the non-central "t" test (Johnson and Welch, 1939), there has been obtained the upper confidence limit L of C at both the 99 and the 95 per cent levels. This means that the chances are 1:100 (or 5:100) that more than one in every 1,000 cabbages treated in a particular manner will have a concentration exceeding L, e.g. exceeding 3.7 (or 3.2) for a 2 per cent dust at 21 days (see Table I).

TABLE I. CONCENTRATION OF DDT RESIDUES ON CABBAGES

Treatment	Period since last treatment (days)	Concentration		μ	σ^2	Confidence limit at level indicated	
		Max. (p.p.m.)	Min. (p.p.m.)			95%	99%
2 % dust	14	3.9	0.7	1.67	0.8	5.9	6.7
	21	1.9	0.5	0.87	0.31	3.2	3.7
1 % dust	14	2.9	0.3	1.38	0.60	3.3	4.5
	21	0.6	0.1	0.24	0.096	2.8	3.2
0.1 % spray	14	2.6	0.6	1.36	0.34	4.1	4.6
	21	1.0	0.1	0.28	0.07	1.6	1.8
0.05 % spray	14	1.7	0.7	1.15	0.058	2.3	2.5
	21	1.7	0.1	0.28	0.157	2.2	2.5

The maximum and minimum concentrations actually found and the values of μ, σ^2 and L are expressed as parts per million on the weight of cabbage after removal of the cover leaves where μ is the mean, σ^2 is the variance of the concentrations and L is the upper confidence limit of C.

There was a significant difference in every case between measurements taken on the 14th day and the 21st day. Significant differences were also found between the 2 per cent dust and the 0.05 per cent spray when the cabbages were harvested 14 days after treatment, and between the 2 per cent dust and the 1 per cent dust for both the 14-day and the 21-day periods.

It can be seen from the table that all the values of L lie below the limit of 7 p.p.m. required by the Food and Drug Regulations 1946.

It is therefore highly unlikely that more than 0.1 per cent of the cabbages treated will have a concentration exceeding 7 p.p.m. even when a 2 per cent dust is used. With other treatments the margin of safety is considerably greater.

In all cases adequate protection from the ravages of the caterpillar has been secured (Taylor, 1945), and it would therefore appear that a 1.0 per cent dust or a 0.05 per cent spray could be recommended to give adequate control and to provide a satisfactory margin of safety in the amount of residual DDT, provided the cabbages are harvested two to three weeks after the last treatment.

ACKNOWLEDGMENT

The authors wish to express their thanks to the Applied Mathematics Laboratory of the Department of Scientific and Industrial Research for the statistical analysis of the analytical data.

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NOTE ON ZINC DEFICIENCY OF CITRUS AT AITUTAKI, COOK ISLANDS

By W. B. HEALY, Soil Bureau, Department of Scientific and Industrial Research, Wellington

(*Received for publication, 10 October 1951*)

Chlorosis of orange trees at Aitutaki was noted in 1949 by the Director of the Department of Agriculture, Cook Islands, and at his request the Soil Bureau undertook to investigate its cause.

The soil on which the trees are growing is a lateritic soil which has received liberal applications of coral limestone. It has been classified by the Soil Bureau as the Tautu silt loam and its analysis is given in Table I. It will be seen that exchangeable potassium is very low. Field trials with this element have been recommended.

TABLE I. SOIL ANALYSIS*

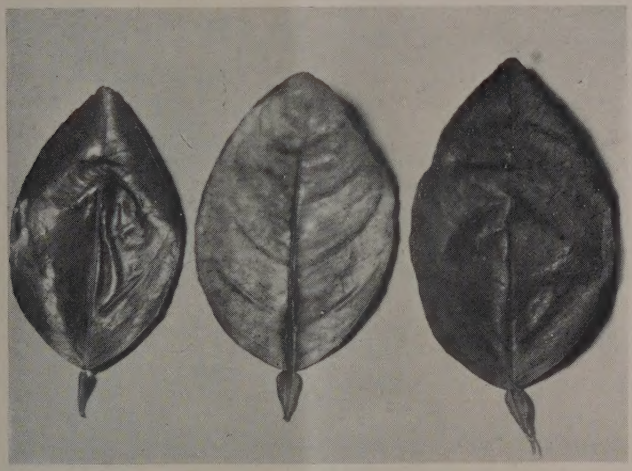
Depth (in.)	pH	P_2O_5 citric soluble (%)	C (%)	N (%)	C/N	Cation Exchange: Exchange capacity (m.e. %)	Total bases (m.e. %)	Base Saturation (%)	Ex. Ca (m.e. %)	Ex. Mg (m.e. %)	Exch. K (m.e. %)
0–5	7·1	0·059	6·8	0·66	10	43·7	46·8	100)	34·4	12·3	0·18
9–15	7·1	0·022	4·4	0·33	13	26·4	28·2	(100)	21·9	6·5	0·08

* Results on oven-dry basis.

The high pH values of the soil and the pattern of chlorosis on the leaves, suggested that a deficiency of one or more trace elements was responsible. Because of the distance of Aitutaki from New Zealand, the first experiment was a simple one, designed to test this hypothesis. It consisted of a spray containing all the trace elements known to be essential for plant growth, viz. Fe, Mn, Cu, Zn, B and Mo. These elements were kept in solution by the use of disodium hydrogen citrate. Instructions for the experiment were sent to the Resident Agent at Aitutaki, Mr. R. M. L. Gladney, who conducted the actual spray trials. Three trees were treated with this spray on 18 January, 1950, and three trees were retained as controls. Within one week of spraying, Mr. Gladney reported that sprayed trees showed a definite improvement.

This indicated that the chlorosis was caused by a trace element deficiency. The next step was to carry out a further experiment using the six trace elements individually. Instructions for this trial were sent to Aitutaki with the request that the previous trial with the "complete trace element spray" be repeated. Spraying was carried out on 16 March, but repeated again on 16 May, 1951, because of heavy rain shortly after the first spraying. Sprays with single elements were made in duplicate, "complete sprays" and controls, in triplicate. The only sprays to produce a response were the "complete sprays" and the zinc sulphate spray. No spray damage was reported for either of these two

sprays but the "complete spray" left some residue. Typical leaves from trees receiving "complete spray," zinc sulphate spray and control trees are shown in Fig. 1.



(*a*) (*b*) (*c*)

FIG. 1.—Response of Citrus leaves to treatment for Zinc deficiency.
(*a*) Treated with zinc sulphate spray.
(*b*) Control.
(*c*) Treated with complete spray.

The zinc content of leaves from the control trees was 7.1 p.p.m. (oven-dry basis). Chapman[1] suggests that leaves with a zinc content of less than 15 p.p.m. will be deficient, and on this basis the leaves from Aitutaki are very low in this element. Total zinc in the 0-5 in. and 9-15-in. horizons of the soil is 38.5 and 101 p.p.m., respectively on the oven-dry basis.

To determine exchangeable zinc, 30 g. of air-dried soil was leached with 200 ml. of normal ammonium acetate adjusted to pH 7.0. The ammonium acetate was the stock reagent normally used in this laboratory for routine soil analysis, and 200 ml. contained 47.6 μg. of zinc. However, the leachates from the 0-5 in. and 9-15 in. horizons of the soil contained only 9.0 and 6.9 μg. of zinc respectively, emphasising the power of this soil to fix zinc.

It is intended to carry out further work on this soil at a later date.

ACKNOWLEDGMENT

The writer has pleasure in acknowledging the interest shown by Mr. R. M. L. Gladney and the efficient way in which he carried out the spray trials.

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NOTE ON AGRONOMIC EFFECT OF THE ENDOPHYTE OF *Lolium perenne*

By J. C. NEILL, Grasslands Division, Department of Scientific and Industrial Research, Palmerston North

In continuance of previous work[1] a randomized, single plant, field trial was carried out in 1951-52 at this Division to compare endophyte-infected and endophyte-free plants of *Lolium perenne*. Plants were grown from 2-year-old and fresh seed of the same clonal line, the former being verified as free and the latter as infected. The plants were cut and weighed individually just before flowering and later grazed by sheep. No significant difference was shown either in weight of herbage or preference in grazing.

It would appear, therefore, from this and the previous work, that the endophyte affects neither the vigour nor the palatability of its host.

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